POWER and THE ENGINEER

EVERYTHING ABOUT THE GENERATION AND TRANSMISSION OF POWER

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IT is an engineer's duty to know more about steam engineering than any other one thing. Duties are generally considered as the disagreeable or undesirable things which must be done.

You don't have to know *more* about valve setting than you do about Hans Wagner's batting average in order to earn your bread and butter in an engine room. But if you do it is probable that your wages will buy more bread and a better quality of butter than if you don't.

It is not absolutely necessary for you to know more about the meaning of the lines of an indicator diagram than you do of the problematic value of a bob-tailed flush before the draw in order to be a good engineer. But you will be a better one if you do. In these pages you will find valve setting and indicator diagrams discussed by men who are interested in such things.

And in some of these discussions you may find an answer to the very questions that you could not answer last week.

The correspondence columns form a sort of experience clearing house where, instead of being charged a percentage, everyone draws a dividend.

There are some questions that are mightily interesting to the engineer which are discussed by our editors, special contributors and a large number of readers. Did you ever stop to think why lead is given? Is it a good thing? Is it necessary? There are a hundred questions that can be asked about lead. Can you answer all or any of them correctly?

You may think so, but how much do you really *know* about the matter?

Do you suppose Uncle Pegleg knows? Well, he knows a whole lot about a whole lot of things that engineers ought to know about, and he is going to show the kid how he can find out for himself if he really wishes it.

And then there is that other question that bobs up once in a great while about balancing the load between the cylinders of a compound engine. One good engineer is not satisfied until the load is equally divided, and another equally good never gives the matter a moment's thought.

Who is right? What do you know about it? Did you ever make any experiments along this line to satisfy yourself or anyone else? If you know, write and tell about it. If you don't know, but think you know, write and tell about that, too.

Add your tithe to the store of information on the subjects in which you are interested. You will be surprised by the amount of value it will net you in pecuniary and other ways. Get the habit.

Boiler Explosion at Reading, Penn.

Small Upright Boiler Explodes and Kills Five Men. Boiler Sheets in Good Condition with No Indication of Old Cracks. Tubes Show No Evidence of Beading at Top Head

BY WARREN O. ROGERS

As briefly mentioned in the issue of January 11, the exploding of a 40-horse-power vertical boiler, one of a nest of four, used by C. A. Sims & Co., contractors of Philadelphia, instantly killed the five men standing about it at the time. These boilers furnished steam for engines running the derrick and concrete mixer, used in building the concrete piers for the coal chutes of the new power plant of the Metropolitan Electric Company, Reading, Penn. These boilers were located about 600 feet from the site of the new power plant, which has only its skeleton work up.

The four boilers were sheltered only by rough board sheds, consisting of a roof and three sides, the front being left open, as shown in Fig. 1, as is the usual manner of housing boilers on this kind of work. The exploded boiler and another of the same size were connected and stood but a short distance apart, which accounts for the fact that the two firemen were killed. An engine runner who had charge of the concrete-mixing engine was also killed, together with a laborer and a rigger. A peculiar feature of this explosion is that beyond the men killed, no one was injured, although there were men in close proximity at the time.

The boiler was located in a hollow angle formed by the Belt Line and Pennsylvania railroad tracks. A general view of the wrecked boiler and surroundings is shown in Fig. 1.

The boiler was, as nearly as could be determined from the bent and twisted condition of the plates, 48 inches in diameter, 8½ feet high and contained 128 two-inch tubes. This would give a furnace diameter of about 43 inches. The shell was made of ⅜-inch plate, but the furnace sheet was not over 5/16 inch thick. This sheet was badly torn and only two small sections, which are shown in Fig. 2, had been found at the time of our visit. The outer shell was torn from end to end, the rupture evidently running from the top to the fire door, taking an uneven course, as shown in Fig. 3. This sheet did not show that the boiler had been in a dirty or scaly condition, neither did the tubes. If the boiler was coated with scale, the surfaces were cleaned by the explosion in a most thorough manner, as might be expected, and no scale or traces of scale could be found adhering to them. An examination of the overturned boiler which used the same feed water and was put in service about the same time showed that it was as clean as a boiler could be expected to be, merely a very thin skin of scale showing on the tubes and shell. From what could be seen there was nothing to indicate that the exploded boiler was in a bad condition regarding scale.

An examination of the fire sheet did not show that it had been burned. A slight amount of pitting could be detected, but it is safe to say that it had nothing to do with the cause of the explosion. That the fire sheet was not as strong as the shell, is evident in the fact that every staybolt pulled out of the fire sheet, as shown in Fig. 2, and, with the exception of a few, were found secure in the outer shell. The condition of the staybolts was, in the main, good, they having deteriorated between the

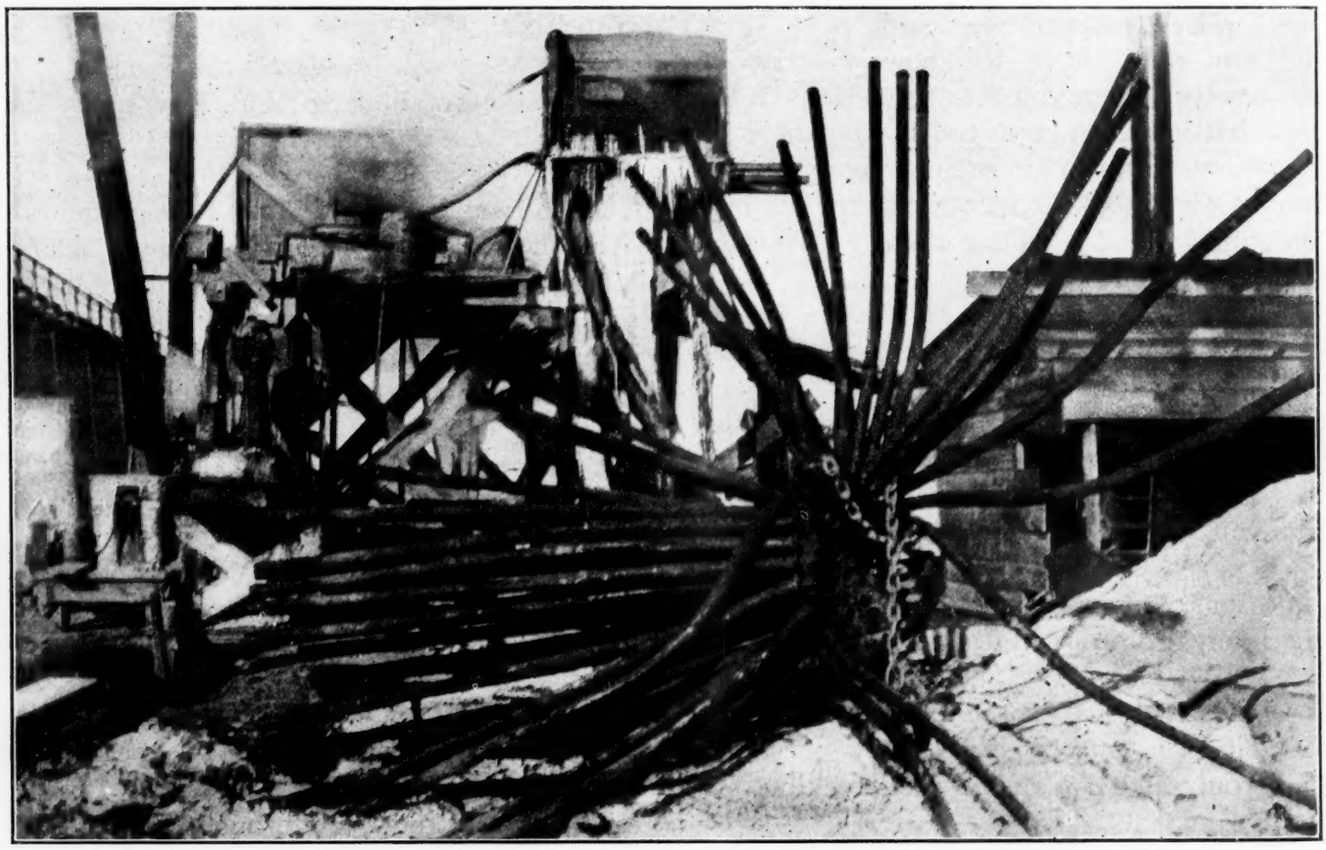


FIG. 1. SIDE VIEW OF WHAT WAS LEFT OF THE EXPLODED BOILER. THE NEW SHED IS ON THE ORIGINAL SITE

threaded ends but little. The threads on some of the bolts were corroded somewhat, which would indicate that leakage had occurred.

left riveted to the fire sheet. (See Fig. 2.) The sudden release of water and steam at the time of rupture accounts for the peculiar spreading of the tubes.

FIG. 2. REMAINS OF THE FIRE-BOX SHEET

A point worth noting is that with the exception of several inner tubes and the entire outer row of tubes, all remained fast in the bottom tube sheet, as shown in Figs. 1 and 4. This tube sheet

Another point to note is that no tubes remained in the upper tube sheet, every one coming out clean and free. Many of the rivet holes in both the top head and top end of the shell were elongated, in

rivets were sheared. Although the outer sheet was bent and twisted, some of the bends being quite sharp, there were no indications of an old crack from which the rupture might have started, neither were there any cracks due to bending of the plate at the time of the explosion. This, together with the fact that the metal around the rivet holes stretched so much before breaking out indicates that the plate was of good material. The maker's stamp of tensile strength could not be found. The boiler shell was blown up over the belt-line track, which is approximately 50 feet above the level where the boiler stood, and landed about 1500 feet distant.

What caused the explosion? The theory of low water is the one most advanced locally, but the very violence of the explosion is proof that the boiler was full of hot water under pressure. The watchman, who cared for the boilers during the night, testified at the coroner's inquest that he turned the boiler over to the day firemen with 2½ gages of water in it. The man who worked on the boiler the day before the explosion testified that he had repaired five leaky tubes (presumably expanded them.) This boiler had been retubed, it is stated, three months before, but the tubes must have given trouble from leaking; hence, the work of the boilermaker. It was also stated at the inquest that the boilers used by this company are supposed to be inspected twice yearly,

FIG. 3. SHELL OF BOILER, BLOWN AN ESTIMATED DISTANCE OF 1500 FEET

fractured through the outer tube holes bending the tube sheet down, as shown in Fig. 1. The outer part of the lower head was either blown to fragments or

some instances to nearly twice the diameter of the rivet holes, in others pulling out through the edge of the shell. Where the rivet holes did not give way, the

but no evidence was brought out that this boiler had been inspected for the past nine months.

The upper tube ends showed no indi-

cation of having been beaded over onto the head and it is not even known whether they were flared or not. At any rate the tubes evidently were not put into the head in the firmest way, else more would have pulled out of the lower tube sheets, at which end they were beaded. There was no means of determining the manner in which the steam gage was attached to the boiler or whether the safety valve was set in such a manner that it could be shut off from the boiler proper, both having been blown away. If the steam gage was piped similarly to that of an adjacent boiler it was decidedly bad practice, as the gage pipe extended out and up about 5 inches from the boiler, the gage being placed on the end of the vertical pipe. This made a direct passage from the steam gage to the boiler with no siphon coil or U-bend between. If the gage on the exploded boiler was connected in such a way, the gage would after a time become unreliable and register false, due to the high temperature of the steam. But assuming that the gage registered correctly, there is a decided probability that the condensed steam in the pipe would not return to the boiler, and that in case of low-steam pressure, such as would be carried at night, the gage might, and most likely did become frozen, thus registering a false pressure. If the gage was connected to the boiler with the regulation coiled tube, the probability of the connection freezing is all the more apparent. The fact that other gages did not freeze does not count, as they were sheltered from the cold wind by their sheds facing a different direction.

Assuming that there was plenty of water, newly rolled but not beaded tubes, a frozen steam gage and hot fire, it takes but little imagination to figure out what would happen. The increasing pressure not registered by the steam gage would tend to burst the boiler, and the weakest place would give first. This would, as far as known, be the tubes in the upper tube sheet. It is natural to surmise that the day engineer threw on fresh coal as soon as he came on duty in order to get up the regular working pressure for the day, which was 100 pounds. As the upper tube sheet was forced out over the end of the tube, the

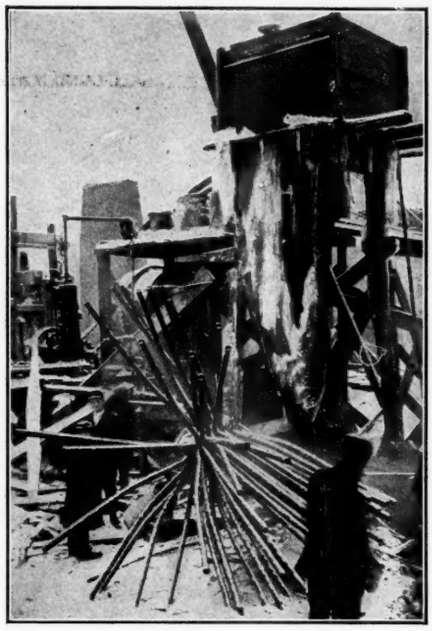


FIG. 4. END VIEW OF THE TUBES

strain would come on the upper row of rivets joining the top tube sheet to the shell, and the flat surface of the upper head becoming practically unsupported by the tube would allow the pressure in the boiler to exert a tremendous strain on these rivets. This would cause the rivet holes to elongate or pull through the sheets, and in other instances shear the rivets, and the final rupture of the shell would follow.

At the same time that the upper head pulled away from the tube, the lower tube sheet would be forced downward, the pressure acting on it would cause the head to shear through the outer row of tube holes.

It is stated that the safety valve had blown the day before which, if true, must be taken account of. If it failed to blow when 100 pounds pressure was reached, there was a reason for it. It would hardly become stuck in less than 24 hours after blowing, due to corrosion, but it could have become frozen if it were not properly piped. No one seems to know how the safety-valve connection was made to the boiler, but if it were placed with a pocket between it and the boiler, a low steam pressure and a cold night, the chances are that freezing would occur.

Did such a thing take place? A combination of frozen steam gage, safety valve, and a boiler exposed to the weather, located on the bank of the Schuylkill river, where the cold winter winds had full sweep, and a fireman working his fire in an endeavor to raise the steam pressure on a frozen steam gage? Nobody knows, but the indications are that the pressure which burst the boiler was above the normal working pressure.

Although the local newspapers have intimated that something was being concealed by the contractors, the writer during his visit to the plant received most courteous treatment from those on the ground, who talked freely of the accident, besides pointing out where various parts of the boiler could be found for photographing and examination. Although the verdict of the coroner's inquest censured the contracting company for not keeping the boiler in proper condition, nothing that could be learned from either the testimony given or the condition of the remaining parts of the boiler indicates gross negligence, with the exception that the boiler was not inspected as frequently as it should have been, and may have been so operated as to have allowed of the order of occurrences above supposed.

Safe Speeds for Cast Iron Flywheels*

The speed at which a flywheel may be safely run depends upon the material of which it is constructed, upon its design, and upon the conditions under which it is used.

The relative fitness of various materials for flywheel rims is measured by dividing the tensile strength T per unit of area, by the weight W per unit of volume. The higher the value of T/W, the better is the material fitted for use in a flywheel rim. The strength of the rim of a flywheel to resist centrifugal force cannot be doubled by doubling the quantity of material in the rim, because the centrifugal force is doubled also when the quantity of material is doubled. It results then, that for any given material, the strength to resist centrifugal force does not depend upon the quantity of material in the rim, but only upon the tensile strength of that material, and for any given material in a flywheel rim there is a definite rim speed or velocity that cannot be safely exceeded.

The formula for determining the safe rim speed of flywheels is as follows:

$$V = 97.8\sqrt{\frac{T}{W} \times \frac{E}{F}}$$

in which

V = Safe rim speed in feet per minute,

T = Ultimate tensile strength of material in flywheel rim in pounds per square inch,

W = Weight of material in flyweel rim in pounds per cubic inch,

E = Efficiencey of joints in flywheel rim,

F = Factor of safety.

In the case of cast iron, an ultimate tensile strength of 10,000 pounds per square inch is as much, probably, as can be assumed with safety. If then a factor of safety of 10 be taken in a wheel with

*From the Fidelity and Casualty Company's book on "The Prevention of Industrial Accidents."

a solid rim, the formula becomes (E being equal to 1 since there are no joints):

$$V = 97.8 \sqrt{\frac{10{,}000}{0.26} \times \frac{1}{10}}$$

or 6060 feet per minute. That is to say, the safe rim speed for a cast-iron wheel made in one piece does not much exceed a mile a minute. More accurately, a cast-iron wheel, made in one piece and well proportioned, reaches the limit of safety at a rim speed of 1.15 of a mile per minute.

But if there are joints in the rim of a flywheel, the factor of safety becomes considerably less than 10. Thus if the efficiency of the joint is only 50 per cent. of the solid metal, the factor of safety in a cast-iron wheel run at a rim speed of 6060 feet per minute is only 5, and if the efficiency of the joint is only 25 per cent. of the solid metal, the factor of safety is only 2½.

It is current practice to operate flywheels at a rim speed of about a mile a minute. The limit of safety, however, varies with the material of which the wheel is built, and in sectional wheels, also with the type of rim joint employed. Knowing the speed of a wheel, and the efficiency of the joint, the factor of safety may be calculated from the above formula.

The margin of safety on speed may be ascertained by taking the square root of the factor of safety on material. Thus, if the factor of safety on material is 10, the margin of safety on speed is

$$\sqrt{10} = 3.16,$$

that is to say, if the wheel reaches a speed of about three times its normal speed it will be disrupted by centrifugal force. If the factor of safety is only 2.5, the margin of safety on speed is only 1.58, or an increase in speed of 60 per cent. will disrupt the wheel. How important it is to keep a wheel from "racing" is thus clear. The stress in the rim due to centrifugal force increases in proportion to the square of the speed.

The following table shows the speeds at which it is safe to run cast-iron wheels of various types of rim joints. The efficiencies stated for the joints* comprised in the table are based mainly on experiments made by Prof. Charles H. Benjamin. In the case of a wheel with no joints, that is, a wheel with a solid rim, the efficiency is of course unity, 1. The usual flanged and bolted joint in belted sectional wheels, with the flanges midway between the arms, has a very low efficiency, only 25 per cent., and very often the efficiency does not run over 20 per cent. This is a very poor design. It may be improved greatly by placing the joints at the ends of the arms, so that the centrifugal force due to the heavy flanges and bolts is sustained directly by the arms, instead of being carried by the rim, and acting on it as a bending force. The efficiency of this type of flanged and bolted joint rises to 50 per cent., and is the same as the efficiency of the pad joint, generally used in wheels made of many sections. In heavy, thick-rimmed balance wheels, where steel links are shrunk on to reinforce the flanged and bolted joint, an efficiency of 60 per cent. may be obtained, but this form of construction cannot be used in belt wheels having thin rims. A still higher efficiency may be obtained by making the rim of the wheel of I-beam section, placing the joints at the ends of the arms, properly proportioning the joints and using steel links shrunk in. This is the method followed in the so-called "Haight" type of joint, described in the February 28, April 11 and August 1, 1907, numbers of the *American Machinist*. It is improbable, however, that any sectional wheel can be made actually as strong as a solid wheel without joints. The subject of rim joints is worthy of much more study and experiment than has been given to it. It is to be borne in mind that

$$V = 3.14 \times D \times N,$$

in which

V = Rim speed in feet per minute,
D = Diameter of wheel in feet,
N = Number of revolutions per minute.

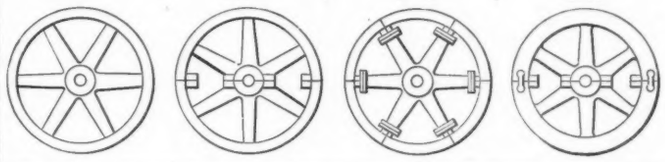
The stress, due to centrifugal force, in the rim of a flywheel made of any material whatever, and also the bursting speed, may be obtained from the following formulas:

$$P = \frac{W \times V^2}{2.66} \qquad B = 1.63 \sqrt{\frac{T \times E}{W}}$$

in which

P = Stress in pounds per square inch,
V = Rim speed in feet per second,
B = Rim speed in feet per second at which disruption will occur,
T = Tensile strength of the material in pounds per square inch,
W = Weight in pounds per cubic inch,
E = Efficiency of the rim joint.

SAFE SPEEDS FOR CAST-IRON FLYWHEELS.

	No Joint 1.00	Flange Joint 0.25	Pad Joint 0.50	Link Joint 0.60
				
Diameter in Feet.	R.P.M.	R.P.M.	R.P.M.	R.P.M.
1	1910	955	1350	1480
2	955	478	675	740
3	637	318	450	493
4	478	239	338	370
5	382	191	270	296
6	318	159	225	247
7	273	136	193	212
8	239	119	169	185
9	212	106	150	164
10	191	96	135	148
11	174	87	123	135
12	159	80	113	124
13	147	73	104	114
14	136	68	96	106
15	128	64	90	99
16	120	60	84	92
17	112	56	79	87
18	106	53	75	82
19	100	50	71	78
20	95	48	68	74
21	91	46	65	70
22	87	44	62	67
23	84	42	59	64
24	80	40	56	62
25	76	38	54	59
26	74	37	52	57
27	71	35	50	55
28	68	34	48	53
29	66	33	47	51
30	64	32	45	49

NOTE—Margin of safety on speed, approximately 3. If the revolutions given in the table be increased 20 per cent., the margin of safety on speed will be reduced to 2½; if the revolutions be increased 50 per cent., the margin of safety will be reduced to 2.

*The efficiencies are spoken of as if they were simply the efficiencies of the joint. This is not strictly accurate. The efficiencies are really the efficiencies of rims with various types of joints as compared with the solid rim, and depend not alone upon the design of the joint, but also upon the design of the rim and upon the bending stresses set up in the rim.

Be careful about closing all the valves to a feed-water heater of the closed type as the expansion might burst it. A good kink for detecting leaks in a closed heater is to tap a small hole in the bottom and put in a valve. If much water comes out, it proves a leak. Of course, some water will come anyway from the condensed steam. If the plant is one which shuts down at night, then is the best time to try it. See that the exhaust pipe is well drained and then start the feed pump at a good speed; if there is much of a leak in the heater, the water will gush out at the valve.

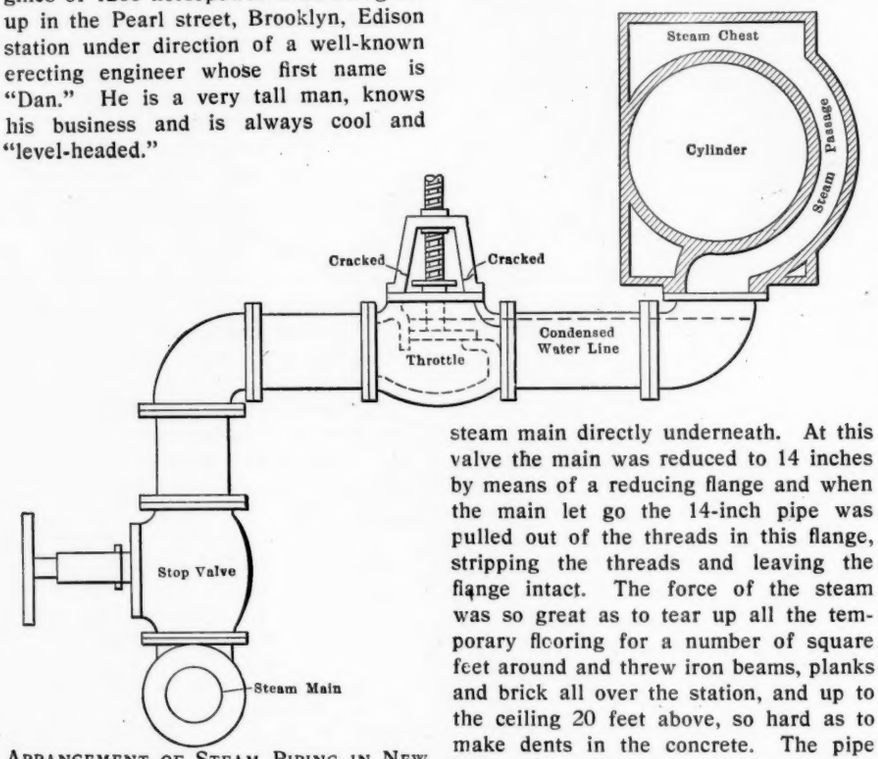
Ready Wit and Heroism in Engine Room

Some Remarkable Instances Where the Good Judgment and Quick Action of Operating Engineers Have Prevented the Loss of Life and Destruction of Property

BY HUBERT E. COLLINS

Every day operating stationary engineers face and overcome danger in many forms. There are many "in the ranks" who would rather die than have it said that they failed manfully to face danger in the engine or boiler room. Civil, electrical, bridge and locomotive engineers have been popularized in current literature, but the stationary steam engineer is seldom heard of, not because there are fewer heroes among them, but because their work is less noticeable.

In the winter of 1894-95 two vertical three-cylinder compound Williams engines of 1200 horsepower were being set up in the Pearl street, Brooklyn, Edison station under direction of a well-known erecting engineer whose first name is "Dan." He is a very tall man, knows his business and is always cool and "level-headed."



ARRANGEMENT OF STEAM PIPING IN NEW YORK PLANT

The Williams engines were set up just back of two Lake Erie engines, which had been in service two years or more. The first Williams engine, farthest from the boiler room, had just been put in service and the second was being erected.

The steam mains were run over the tops of the batteries of boilers, dropped to a point below the boiler and engine rooms and out between the engine foundations, and from there the supply was taken up through the engine-room floor separately to each engine. The Holly system of drainage was used on the steam mains and its installation was a new thing at that time and place, in consequence of which the operating engineers in the station were not familiar with it and were having trouble to keep the lines clear of water.

For two or three days there had been trouble, until one day it resulted in a bad explosion in the steam main caused by water hammer. The surging was so violent that the handwheels on the valve stems vibrated on the floor stands above the floor. As time went by and the trouble was not stopped, several of the erecting gang on the new engine began to watch for trouble. "Dan" stood on temporary flooring with one hand resting on the handwheel of a 16-inch gate valve in the steam main directly underneath. At this valve the main was reduced to 14 inches by means of a reducing flange and when the main let go the 14-inch pipe was pulled out of the threads in this flange, stripping the threads and leaving the flange intact. The force of the steam was so great as to tear up all the temporary flooring for a number of square feet around and threw iron beams, planks and brick all over the station, and up to the ceiling 20 feet above, so hard as to make dents in the concrete. The pipe let go with a final surge of the water and "Dan," who was immediately over the point of rupture, was last seen in a cloud of steam and flying débris, apparently doomed.

But with the explosion he had leaped and his long legs enabled him to reach in one bound the nearest engine foundation. One man watched "Dan" and joined him, and together they succeeded in closing the main stop valve in the line leading into the engine room, about 20 feet back from the 16-inch stop valve spoken of. Several men pushed into the steam-filled room to rescue "Dan," but by the time he was located he and his assistant had the flow of steam shut off. Although twenty men were in the room at the time, they escaped serious injury and several who were penned in the cellar owed their lives to "Dan's" cool head and quick action, for they could not have escaped had steam flowed much longer.

The force of this explosion carried the section of 14-inch pipe, with a blank flange on the end and about 12 feet long, straight ahead and through a 16-inch brick wall some 10 feet away.

This explosion had a sequel in another on the Sunday night following. The same charge of water which caused the rupture in the steam main was carried into the high-pressure cylinder of the 1200-horsepower engine which was running at the time the pipe let go. This evidently cracked the high-pressure piston, but it was not known until after the second explosion. The steam main had been repaired as quickly as possible and this engine was started one Sunday afternoon. After being in service over an hour the cylinder head and piston came out at once, causing a very bad wreck. The pieces of cast iron, some weighing 50 pounds, struck the engine-room ceiling and, rebounding, fell in all parts of the engine room. In the midst of this flying iron and escaping steam, an old man (Mr. Hulse, the engineer on watch) made his way to the throttle immediately under the damaged cylinder and shut off the steam. His nerve can be judged when it is known that the throttle was a rising-stem valve that took several seconds to close; but he stood in a shower of hot water, steam and flying iron and performed his duty. It is said that he did not even lose the light in his brierwood pipe, held in his mouth all the time. He suffered a few slight burns, but was on duty next day.

In a certain power house near New York a few years ago was enacted another incident of this nature, the causes of which may prove a lesson. It was a high-pressure steam plant in which the engines stood idle nearly all day, the principal load being in lighting service. In this instance, also, the steam mains were run in the basement, each engine being supplied with steam from underneath. Two horizontal tandem-compound Corliss engines took steam from these mains in the basement, the supply line being tapped from the main below and leading to the steam chest of the high-pressure cylinder, about as shown in the accompanying sketch. This sketch shows a cross-section through the cylinder, showing how steam passed from underneath, around the side of the cylinder to the steam chest. It also shows one stop and one throttle valve between the steam main and the steam chest.

The throttle valve was a soft-seat globe valve with a brass rising stem passing through the stuffing box and threaded into a stationary nut in the valve yoke. The body of the valve and yoke was cast iron. This valve yoke came up through the floor and was covered by a floor stand on which was placed the handwheel to operate the valve. This valve was properly connected up with the pressure underneath the seat. For a considerable time prior to the incident about to be related, the throttle valve had been leaking, as was evidenced by the fact that the engine while standing idle would creep over so that the crank would get on dead center before next starting-up time.

It finally became a custom for assistant engineers or oilers to take a starting bar, or even a crowbar at times, and placing it in the handwheel, jam it up as tightly as possible. This practice was condemned by one of the assistant engineers, who made complaints to no purpose, as the custom prevailed.

Finally there was need of making minor repairs to the high-pressure cylinder. It was opened up, and the leaking steam bothered the men so while working on it that the bar was often used on the throttle valve, and the stop valve was closed on the steam main, also.

That evening at starting-up time the assistant engineer sent his oiler below to open the stop valve next to the main. The oiler first cracked the valve to warm up and after about 10 minutes went below again and opened the valve wide, which put the pressure up to the throttle. Now the section of pipe from the throttle to the cylinder was not drained and with the engine idle and steam leaking in, this pipe filled with condensation, up to the line shown in the sketch. The assistant engineer had been standing with one hand on the wheel of the throttle, while the oiler was below opening the stop valve. He then stepped down along the crosshead slide for a last inspection before starting up, and had turned to go back to the throttle when the whole top of the steam chest on the high-pressure cylinder blew out, without warning. It was rather unusual for a steam chest to blow out with the engine standing still and no steam turned on, apparently. The top of the steam chest went up in one piece mostly and this one large piece came down exactly where the assistant was. He saw it just in time to step into the recess of a large iron column, and escaped death by the fraction of a second. He instantly stepped over the casting and, rushing into the basement, closed the stop valve so quickly that no further damage was done and no one was injured.

Examination showed that the yoke of the throttle valve was broken off, allowing the steam, at 125 pounds pressure, to lift the valve, rush in and ram whatever water lay in the pipe through the passage and against the top of the steam-chest wall, causing the rupture. The initial cause of the trouble was undoubtedly the pernicious practice of trying to make a leaky valve tight by forcing it shut with anything else than the handwheel, thereby fracturing the yoke.

But to return to the subject in hand: When the fracture occurred, the place was instantly converted into a roaring, hissing inferno into which the engineer was introduced without warning. In the first second of this time he sidestepped death and instantly started to stop the destruction by closing the valve. He had to rush through blinding clouds of steam and hot water, but performed his first duty so quickly that others rushing in arrived in time only to see the valve closed.

The following incident shows how training in recognizing the right thing to do and doing it in the same instant saved one man's life. A vertical McIntosh & Seymour engine had been overhauled by a repair firm. The speed of the engine was to be changed and more weight was placed in the pockets of the governor-weight arm. These weights had been allowed to project beyond the pockets about one inch, possibly more. The superintendent of the repair firm was on hand to start the engine on its first run and test the regulation. The throttle was low enough to be operated from the floor. By taking two steps in the right direction the operator was opposite the rim of the governor wheel, where he could watch the action of the weights as the speed increased. The governor wheel was between the housings of the high- and low-pressure sides and from the high-pressure frame under the main bearing there extended a cast-iron oilpan to catch the oil from the governor eccentrics, as well as the main bearing. The operator while watching the governor weights was just back of this oilpan.

He started the engine and, after running it slowly for several minutes, started to speed her up. A little turn on the throttle and a couple of steps to watch the weights, then back to the throttle, was the procedure. In due time the weights were observed to rise from their inner stops. While watching them the operator felt something hot lodge in his hand and, looking at it, saw that it was a tiny piece of lead. Instantly divining that the lead came from the weights and that they were striking, he stepped to the throttle and shut it. As he turned and stepped to the throttle something dark flew by in the place where one step took him from and about breast high, and a second later there was a loud clatter in the far end of the engine room. By the time the engine stopped, men came running to see what the trouble was.

Investigation showed that the new weights, being too long, had struck the oilpan from below as they began to work out with increasing speed. The force was great enough to break a casting ½ to ¾ inch thick and 24 inches across by 18 inches wide, and throw it up about 50 feet and land it 150 feet away, where it lit on edge on top of a new concrete foundation and chipped out a piece of this about 2 inches thick and 6x8 inches. No damage resulted aside from this, but the amount the little piece of lead as warning and the quick action of the operator saved himself from can be calculated from the amount he values his life.

The piece of lead told the operator that something was wrong, and warned him to stop the machine to save property. He acted at once and saved his own life thereby.

The instances given in the foregoing show some degree of bravery on the part of the men involved, a determination to perform duty irrespective of danger, and a ready wit.

Engineers are at times called upon to perform hazardous duties where they are given to understand the risk and have the choice of going ahead or backing out. That they do not always "back out" is well illustrated in the following incident. In this instance the designers could never have completed their work without the aid of the "nerve" and will of the operating engineer, and how well the latter was repaid for this service will readily be noted;

About twenty years ago J. L. Murphy, an operating engineer, was looking for a new position in western Pennsylvania, and one day he was approached by the superintendent of a new rolling mill. This superintendent said that he had a position requiring a man of nerve, laying special stress on this requirement but not telling why. Murphy thought he had the usual amount of nerve and said he was ready for anything. When he reported for duty he was told again that they wanted a man who was not afraid and who would do just as he was told. Again signifying his willingness to go ahead, he was shown a good-sized double engine, each crank being on one end of a roller shaft, ready to start up. He was told to get her ready to run and when the word was given his instructions were to *give her a full throttle ahead.*

So, after a billet of iron had been prepared for the rolls, he was given the word and obeying instructions he threw full gear ahead and gave her full throttle. The result was a complete wreck of the engine. The main shaft broke off near one crank disk and tore loose from its main bearings, breaking the frames as well. Murphy shut down almost as soon as he started and, finding himself alive, waited to be blamed for the wreck. But the superintendent just asked him if he still had his nerve, and being assured that he would stick, he put Murphy at work with a gang to clear up the wreck.

After a few weeks the new parts, but

heavier, were in place and a new trial was made. Obeying the same instructions Murphy again threw her open at the given time and again a wreck resulted. This time the frame on one side gave way, but the shaft held. Again no fatality resulted and Murphy helped clear the wreck. After the second trial he was told that a new process of rolling was being tried and they had no means of knowing exactly how strong to make the various parts only by trial. Murphy entered into the spirit of the matter and willingly handled the throttle for the third trial, which was successful and everything held. But soon after the last trial was made, these mills shut down and after about four months of work and three times up to risk his life Murphy was hunting another job.

To illustrate how fate deals out her portion to engineers in a seemingly inconsistent manner, the following is related:

Robert Wormald, at present a chief engineer in one of New York City's largest apartment houses, was in the United States navy acting as assistant engineer on Admiral Dewey's flagship during the battle of Manila. He served his full time, including service during the time of the Spanish-American war, and received his honorable discharge, leaving the service without an injury of any kind. His first service ashore was in a Newark, N. J., factory. In this place they had a 250-horsepower Corliss engine, built originally for steam pressure under 100 pounds. About the time Wormald took charge the steam pressure had been raised to 125 pounds. The throttle valve on top of the cylinder was of the angle-globe type, and the bonnet was secured only with four bolts. Just as Wormald shut her down one day, this bonnet on the throttle valve blew out, carrying the handwheel, valve stem and valve with it. Wormald stood directly in line of this flying mass and was knocked down and made unconscious by the blow. The scalding steam and water poured over him until his comrades pulled him out of the room at the risk of their lives. He was taken to the hospital, where there was no hope of his recovery. His injuries were horrible. The whole upper part of his torso was parboiled. One strip of flesh from his left elbow extending up along the inside of his arm to the armpit and chest dropped out. Even today a hollow groove nearly one inch deep, and wider, shows the result of his experience.

Skin grafting was necessary to cover both arms, chest and back, yet after some months in the hospital he recovered and is today as capable of doing a full day's work as any other man.

These incidents of real life among operating engineers are only a few of thousands which prove that the man in the engine room has dangers to deal with and the great majority of operators do meet emergencies with nerve, fortitude and skill. When considered in the proper light, these heroes of the engine room deserve great credit, and often the pay they receive is little enough for services rendered.

Suggestion for a Fuel Oil Burner

A Design in Which the Oil Is Heated to Such an Extent before Entering the Nozzle that Enough Vapor Is Formed to Atomize the Remainder of the Oil in the Furnace

BY H. B. STILZ

The merit of a fuel-oil burner rests on its ability to reduce the oil to the highest degree of atomization and then cause it to mix uniformly with a supply of air to support combustion.

Two general types of burners are in use: one in which a jet of steam is used to blow the oil into the furnace and the other in which the atomization is effected mechanically. The burner here suggested combines the advantages of both types.

Fuel oil consists of a mixture of oils having different densities and boiling points, some of which usually can be vaporized at a relatively low temperature. This condition is utilized in the present case in heating the oil before it enters the nozzle to such a degree that there is sufficient vapor formed to effectually atomize the remainder of the oil when it enters the furnace. The nozzle is so constructed that in the absence of vapor, the oil will be atomized by mechanical means alone.

That preheating the oil is conducive to economy is a demonstrated fact. The difficulty encountered with the ordinary burner is that the degree of preheating is very limited, especially with Texas and similar crude oils, for if carried to a point where an appreciable amount of vapor is formed, the burner will give an unsteady flame caused by a succession of puffs from the nozzle due to the supply of oil alternating with the supply of vapor.

Oil will not ignite until it has been

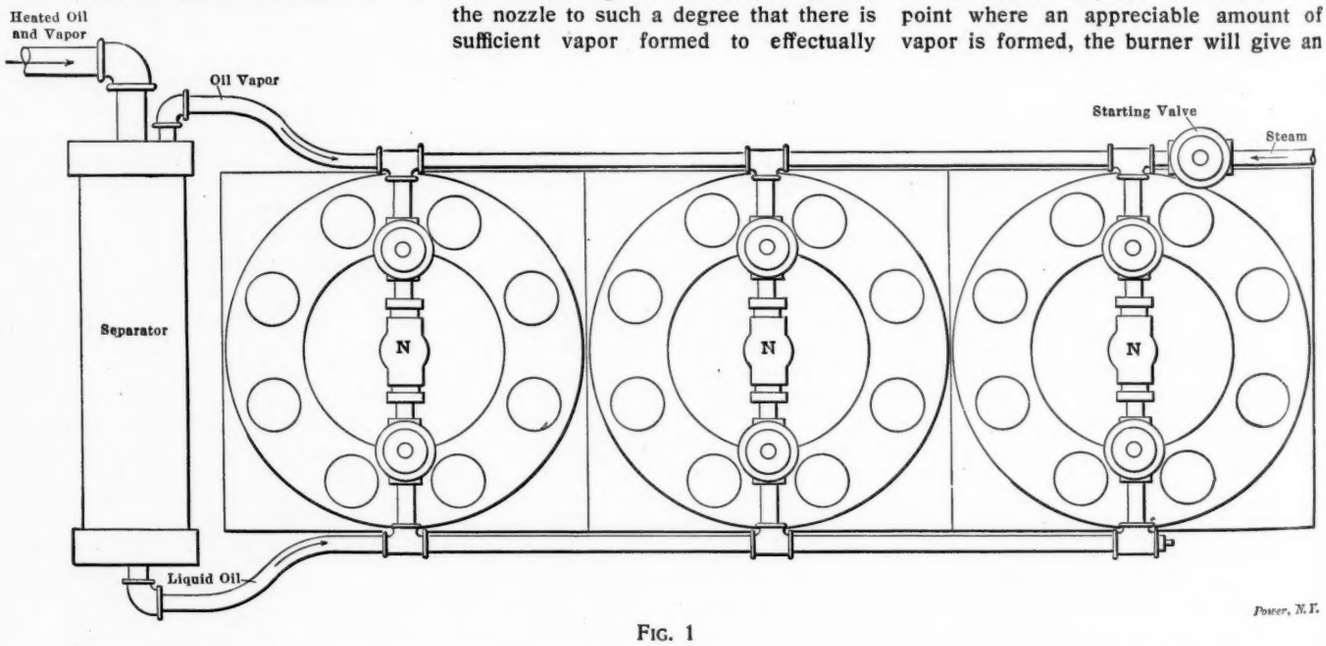


FIG. 1

vaporized and although the rate at which vaporization is effected within a furnace, under normal conditions, is extremely rapid, the velocity of the oil from the nozzle is likewise very great. On this account the oil must be reduced to the highest degree of atomization, since the rate of vaporization is proportional to the extent of diffusion of the mass injected.

Although either mechanical atomization or atomization by means of a steam blast will give good results, still better results are obtainable by a combination of the two. By increasing the amount of oil vapor in the jet from the nozzle, combustion will commence sooner and the combustion zone will be concentrated near the nozzle orifice, where the air supply is strongest and so directed as to mix thoroughly with the atomized oil and vapor. A more perfect mixture is thus obtained than could be had if a portion of the oil reaches the back of the furnace, or in extreme cases the smoke-stack, before it is wholly consumed. In this case an excess of air would have to be supplied in order to insure a sufficient amount being present throughout the extended firing zone.

With excess of air the resulting temperature of combustion of the gases is of course reduced, the increased velocity accompanying the larger volume permits less time for the delivery of heat to the boiler tubes and the loss up the chimney is excessive. Moreover, as the result of tests it is found that when forcing the boiler some of the oil reaching the cooler boiler tubes leaves a deposit of carbon thereon, reducing their conductivity.

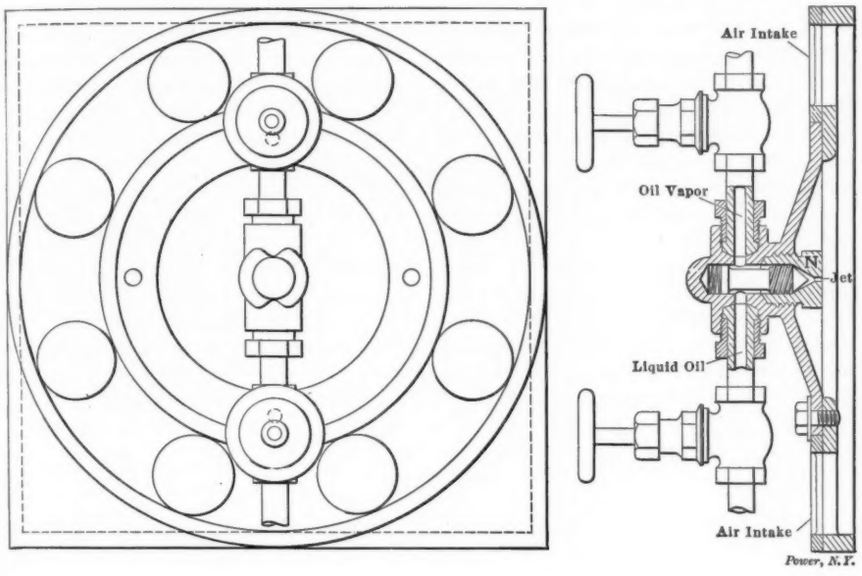


FIG. 2

As outlined in Fig. 1, oil, which has just passed through a suitable heater, is delivered under pressure into a separator, where the vapor generated from the oil while in the heater is separated from the liquid oil, the two being conveyed separately to the nozzles *N* through pipes. The fluids mix uniformly within the nozzle and in passing through the spiral there, they are given a whirling motion which causes them on escaping from the orifice to assume the form of a conical spray. Moreover, the jet is of such a nature as will induct into the furnace an ample supply of air to support combustion.

In starting a fire with cold oil in a cold furnace, a supply of steam or compressed air is admitted to the system through the starting valve. When normal firing conditions are established, this valve may be closed. This connection is necessary in any type of burner to blow out the nozzles, but here it is also adapted for starting cold.

The level of the oil within the separator will be maintained approximately on a line with the nozzle orifices, for if above this level the proportion of oil to vapor flowing to the nozzles will be increased, and *vice versa*. Since the resistances to flow through the supply pipes would probably correspond to an inch or so of head within the separator, and can be made almost anything desired by means of the valves in the supply branches to the nozzles, it is practicable to maintain automatically a steady flame by separating the oil and vapor into steady streams to the nozzles. The inertia of the moving streams works to the same end in taking care of any sudden fluctuations of head in the separator.

If desired, the burner may be operated like those using steam as an atomizing agency, or it may be operated similarly to and as well as the ordinary mechanical atomizing burners now on the market, for if the oil is not heated to a point where there is an appreciable amount of vapor generated in the oil-supply pipe, the separator will neither help nor hinder the operation of the system. Steam heaters might be dispensed with by arranging heaters in the uptakes where the temperature is never above that at which a dissociation of the oil takes place and a carbon deposit is formed, and this is the only condition which must be fulfilled for the burner described.

Development of Michigan Water Power

BY NORMAN B. BEASLEY

The merger of electrical, gas and traction lines by the Hodenpyl-Walbridge, Clarke and Foote interests is the first big step toward the actual electrification of Michigan. The now somewhat shadowy plans for the future five of six years are almost amazing, yet perfectly practicable. They include nothing less than making hydroelectric power in such vast quantities that it can be sold so cheaply that the average farmer will use electricity for light.

The properties of the syndicate are to be rearranged that the electrical companies are separated from the gas properties, and the hydroelectric properties are the most important in the deal. It is proposed to construct 13 dams on the Au Sable river to generate nearly 100,000 horsepower. None of the dams and generating stations will cost much less than $500,000, and several will cost more. Manufactured in such enormous quantities the current can be sold cheaply.

At the same time a statement from the company's office shows that what is true of the Au Sable river is also true of the Grand Rapids & Muskegon and the Commonwealth Power Companies. The engineers' reports show that but a fraction of the power that can be developed is now in use by either of these companies.

According to an official of the company there need be no apprehension because of this merger. The properties now in operation are all controlled by franchises that fix the rates and they cannot be increased. The hydroelectric proposition will mean a tremendous advance industrially in Michigan, and it means that in a few years Michigan will be one of the foremost States, industrially, in the union. There is scarcely no end to the possibilities, for the newly organized company touches but three of the State's streams and cannot for several years to come utilize the power these three streams will generate.

High and Low Water Alarms for Boilers

Descriptions of Various Types of Apparatus Now in Use, Giving Some Practical Suggestions for Their Location, Connection and Operation

BY W. H. WAKEMAN

Fig. 1 illustrates the first boiler that I ever had charge of, and the first low-water alarm that filled me with consternation. The former is still known as the locomotive boiler, but the latter has long since passed into oblivion, or at least into disuse, so far as general practice is concerned. This first experience was secured in 1875, and the low-water alarm was located as shown in compliance with a city ordinance, which stated that all boilers used in that city should be equipped with this safety device as a positive preventer of boiler explosion. Previous to the enactment of this law, a boiler located near the center of the city in question had exploded and caused the death of twenty-two persons, and the only cause given by those immediately concerned in the catastrophe, and believed by the general public, was lack of water sufficient to cover the plates exposed to the action of heat.

When viewed in the light of our present knowledge of the subject, it seems at least strange that anybody could believe that there was only one cause for boiler explosions, but for several years after this first experience I heard no other cause mentioned, and it was by reports published by the Hartford Steam Boiler Inspection and Insurance Company that the many real causes for these destructive failures were made plain.

I very naturally supposed that if the neglect of one man caused the loss of so many lives and the destruction of thousands of dollars worth of property, he would at least be discharged in disgrace, and never allowed to have charge of a steam boiler again; hence I was greatly surprised to find that the engineer in charge of the exploded boiler, who was also the fireman and water tender, was still in charge of the machinery in that plant after the wreckage was cleared away and a new boiler set. The reason given by the owner for this action was that nobody could have prevented what they called an accident, hence their engineer was not to blame. This was not due to any particular regard for the engineer or his abilities, but to save the expense of paying damages to the relatives and dependents of those who were killed, and directly to those who were injured.

The main part of this low-water alarm is attached to the front head about 3 inches above the crown sheet, for a small boiler, while a smaller pipe is tapped into the dome, in order to secure dry steam. A power pump was installed for the purpose of drawing water from a driven well and forcing it into this boiler, but it was almost impossible to bring water up to this pump because the strainer offered much resistance to the flow of water, and pressure of the atmosphere cannot act directly on the surface of water outside of such a well and thus force it up into the pipe. This pump was driven by a pulley on the crank shaft, and it was customary to remove the governor belt and run the engine as fast as was safe, until water appeared at the pump, after which the governor belt was replaced and water was assured for the remainder of that day.

When this boiler was installed, it was filled with water to the second gage by hand, a fire was built in the furnace and efforts made to secure water by the pump, which were not successful the first day. While we were working on the pump the water level was lowered until it left the front-head connection uncovered. Steam was thus allowed to enter this pipe and passing upward melted the soft metal with which the head of the device was filled. This action released the whistle valve and in an instant a shrill blast startled all who were near. Somebody opened the safety valve, and somebody else drew out the fire in record time. Of course, the safety valve ought not to have been opened, but our experience was limited at that time. As the metal which prevented the whistle from blowing under normal conditions was gone, it was necessary to remove the device and have it repaired before it could be used again. The objection to this was the delay caused, and the expense incurred. On the other hand, it was a valuable feature, because it assisted materially in causing us to be more careful. However, as no more boilers exploded, the excitement subsided, the ordinance was repealed and the use of high- and low-water alarms is now optional with all steam users in that city.

Fig. 2 illustrates a similar device except that only one connection is required, and an angle valve is provided for shutting off the alarm whenever it needs repairs. The objection to the presence of this valve is that it may be shut when it ought to be open, hence the fireman or water tender may allow the water level to fall lower than it ought to, and no alarm will be given. However, it should be considered a necessity, and suitable measures taken to prevent unauthorized persons from meddling with it. If a water tender closes it to prevent an alarm from being given on account of carelessness and neglect of duty on his part, he should be reprimanded, and if the offense is repeated he ought to be discharged.

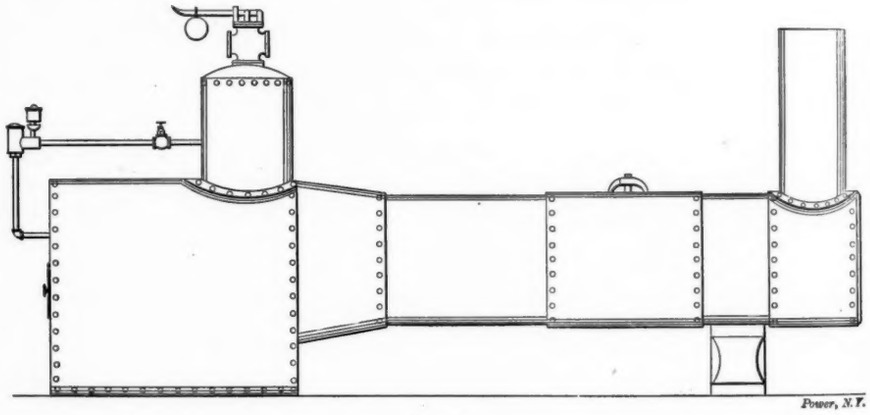


FIG. 1

This low-water alarm operates as follows: As long as the inlet is covered by water, the vertical pipe remains cool, as there is no circulation through it, but if the water level falls low enough to uncover the inlet, steam enters the pipe and, ascending to the top, melts the soft-metal plug which covers the whistle inlet, as it is made of an alloy that melts at 212 degrees Fahrenheit. Having melted the plug, steam blows freely through the whistle, giving an alarm with no uncertain sound.

In order to restore normal conditions, shut the angle valve to stop the noise, and open the drip cock to let out the water standing in the pipe. Pump water into the boiler until the alarm-pipe inlet is covered, and do it without delay, for although the front-head connection shown is, or ought to be, set high enough to

blow the whistle before the upper tubes in a tubular boiler or the crown sheet of a locomotive boiler are damaged by heat, or are liable to be warped by the introduction of more water, still the water level will soon become too low for safety, especially as the alarm is sure to distract attention from everything else.

Unscrew the whistle, put in another plug, screw the whistle down hard on it to make a tight joint, then admit water to the pipe slowly (after closing the drip cock), for unless this is done cautiously the new plug will be melted by heat, because the temperature of water in an ordinary boiler used for power purposes is much above 212 degrees. This alarm

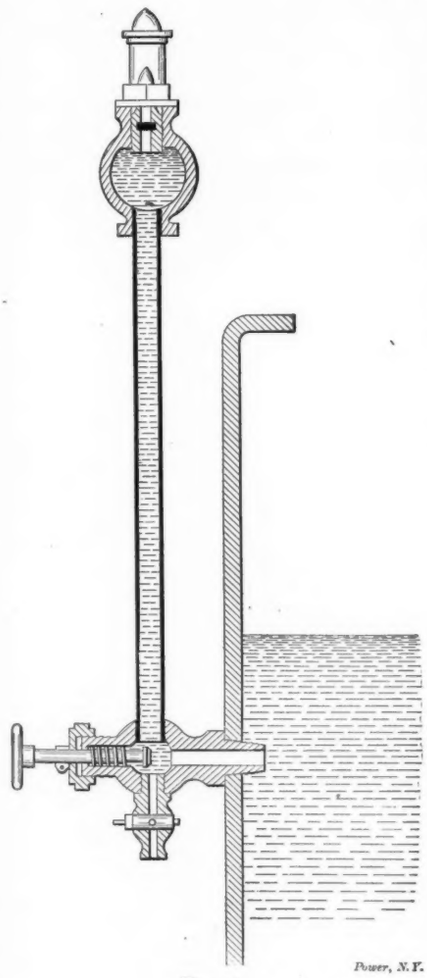


FIG. 2

can be attached to the shell of a vertical boiler where it will be equally effective.

The following alloy will melt at about 212 degrees Fahrenheit: Lead, 1 part; tin, 3 parts; bismuth, 5 parts. It is claimed that any alloy of which bismuth forms a part is not reliable for this service, because it will not retain its original nature indefinitely, hence will fail to melt when it ought to. It is quite possible that this refers to regular fusible plugs as used in steam boilers, as they are exposed to very hot water on one side, and the temperature of a fire on the other, hence pure Banca tin is recommended for them; but this metal is useless for the low-water alarms illustrated in this article, because it requires a temperature of 445 degrees to melt or fuse it. Of course these fusible plugs are exposed to a much higher temperature on one side only, as the pressure of steam must be raised to 400 pounds absolute in order to secure this temperature, and that is seldom or never realized, even in these days of high pressures. The fire does not melt them because heat passes rapidly into the water, but steam at the same temperature has a very different effect, causing the plugs to melt.

Fig. 3 illustrates another device for giving an alarm when the water level is approaching the danger line. It is attached to the shell, but projects down through it far enough to submerge the lower end when the water level is right for working conditions, but when it falls to a depth of about 4 inches over the upper tubes, or flues, as the case may be, steam enters the vertical pipe and, melting a soft-metal plug in the body of the device, causes the whistle to blow.

When this happens, shut the valve, pump in more water, remove the whistle, put in another plug, replace the whistle and open the valve slowly. Care must be taken to make tight joints, for even a slight leak will cause a circulation that may raise the temperature high enough to melt the new plug when there is plenty of water in the boiler.

Superficial examination of this device,

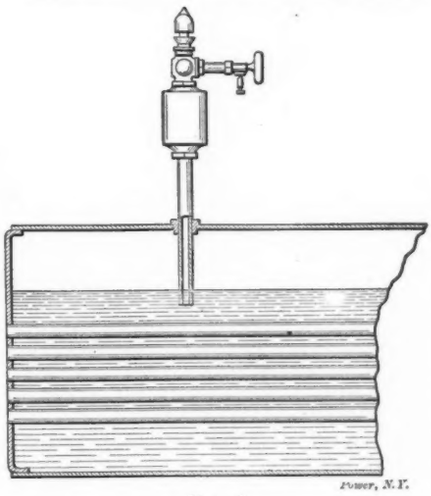


FIG. 3

in connection with the knowledge that water and steam in a boiler are of the same temperature, will cause a fireman to wonder why the alarm operates as described. This point is made clear when he remembers that under working conditions water will not circulate through this vertical pipe, but will go up into it and stay there until it becomes comparatively cool, provided every joint is absolutely tight. If the water level falls low enough to allow steam to enter the end of this pipe, conditions are at once changed. The full temperature due to the pressure carried is transmitted to the plug, and when condensation due to radiation results in the appearance of water at this point, it runs back into the boiler and is replaced by more steam until the plug melts.

On a certain occasion I stated that water and steam in a boiler were of the same temperature (as herein mentioned), and was promptly corrected by a listener, who stated that he pumped cold water into his boiler and the plates around the feed pipe where it was tapped into the boiler were cool, hence water could not be as hot under these conditions as the steam above it. So far as his limited comprehension of the subject would admit, he was correct, but in all such cases it is expected that common sense will be used and intelligently applied. Of course it is generally understood that when the foregoing statement is made it refers to water that has been in a boiler long enough to attain its highest possible temperature; also, that the boiler is designed so that circulation is at least nearly perfect. Although water has the same temperature under these conditions, it does not flash into steam, because it lacks the latent heat required by the process of generating steam.

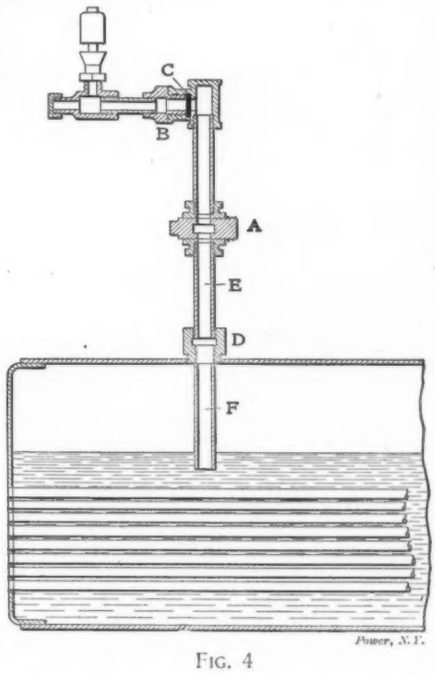


FIG. 4

Fig. 4 illustrates another low-water alarm in which a soft-metal plug is an important feature. It is attached to the shell and extends down through it to the low-water level, wherever that may be. While this depends on the judgment of the engineer in charge, after taking all conditions into consideration, there are few cases in which the water should be less than 4 inches deep over the tubes of a tubular boiler, or the crown sheet of the locomotive type, when the whistle blows, and 6 inches is better in many cases.

When the whistle in Fig. 4 blows for

low water, the plug cock *A* must be closed and more water pumped into the boiler. Unscrew the cap *B*, remove what remains of the plug *C*, insert a new one, screw on the cap until it is firmly seated and open *A* slowly. If a globe valve is used here, there will be less danger of it sticking fast when it ought to work freely, and it can be repaired with little trouble and small expense.

A special bushing is shown at *D*, into one end of which the pipe *E* is connected, while *F* is screwed into the opposite end, leaving a small space between them. Care should be taken when making up such a fitting to know that the pipes enter far enough to secure a firm hold, also that there is an open space between them as illustrated. The shells of many boilers are only ⅜ inch thick, while some are less; therefore, a first-class job cannot

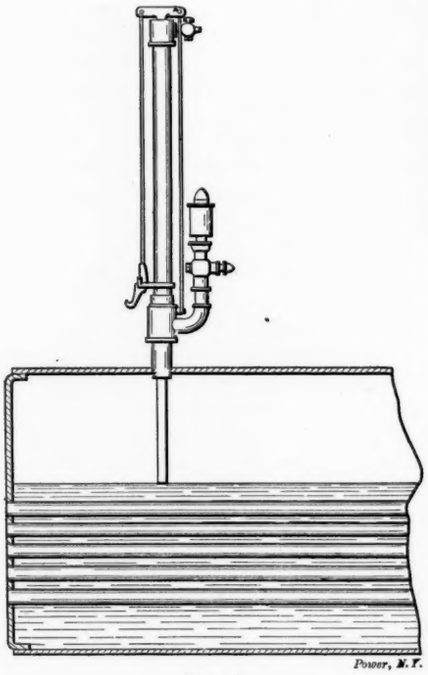


FIG. 5

be secured by screwing in the bushing from the outside, as there are not enough threads available. By starting the tap from the outside, and finishing it from the inside, it is practicable to insert the bushing from the inside and thus prevent it from blowing out, even if the threads are corroded by long service until they no longer are strong enough to resist the pressure put upon them.

An objection to all kinds of low-water alarm which depend on the melting of a plug for their operation is that they cannot be tested in service, therefore it is impossible to know their true condition. Of course it is possible to let the water level fall until the whistle does, or ought to, blow, and observe the result, but in either case it becomes necessary to insert a new plug that has not been tried, thus restoring the uncertain element. The following plan is recommended for such cases: Secure a dozen plugs made from the same alloy. Insert one and test it by lowering the water level until steam enters the pipe. If the plug melts promptly, it is good evidence that they are reliable under given conditions for one year, hence a new one should be inserted annually. The time may be shortened if greater safety is demanded.

Fig. 5 illustrates a device for blowing a whistle when the water level falls too low for safety, the operation of which is based on the principle that brass and iron do not expand equally when heat is applied. Under normal conditions the lower end of the vertical pipe is submerged in water. As soon as the water level is lowered until it begins to assume the position shown in the illustration, all water runs out of the pipe and is replaced by steam, but it is not admitted to the whistle by this action. The temperature of the pipe, which is made of brass, is raised and it is lengthened accordingly.

The rods on either side of the pipe are made of iron, but inasmuch as the coefficient of expansion for brass is about 50 per cent. greater than for iron, the pipe expands more than the rods for an equal rise in temperature, and it is quite possible that the latter are not as hot as the former while in service, because steam does not come into direct contact with them, hence the actual difference in expansion is greater than the foregoing implies.

As the rods are anchored at their lower ends, the difference in length causes the whistle to open and admit dry steam from the upper part of the steam space, thus giving the alarm in time to prevent damage from low water. When the usual water level is restored water fills the pipe, again causing it to contract and close the whistle valve. This alarm can be tested by opening the pet cock shown at the top and allowing hot water to circulate through the pipe, thus raising its temperature the same as if steam were admitted to it, without lowering the water level.

In case the whistle does not blow when this test is applied, the rods should be shortened by nuts provided for this purpose, until the valve is barely open. If the whistle continues to blow after the standpipe becomes cool, the rods must be lengthened by adjusting the nuts in the opposite direction.

Fig. 6 illustrates another low-water alarm which is operated by the expansion of a brass pipe, but the claim that is plainly made for it to the effect that it depends on the difference in the expansion of two metals is apparently not warranted. The claim is as follows: The left-hand vertical pipe is made of wrought iron, and as it is connected directly into the steam space of the boiler, it is always full of dry steam up to the valve just below the whistle. The right-hand pipe extends down below the normal water level, hence is filled with water under working conditions and usually is comparatively cool because there is no circulation through it, as it forms what is known in hydraulic work as a "dead end."

This pipe is made of brass and terminates in a cap on which rests an adjustable screw carried by the outer end of a bell-crank lever. The upper end of this lever rests against the stem of the whistle valve, and the screw is adjusted so that when the pipe below it is cool, the lever touches the whistle valve lightly. When this pipe is heated by steam on account of lowering the water level, it expands, raises the horizontal end of the lever, causing the vertical end to open the whistle valve and sound an alarm that continues until the water level is raised, as no valve is provided for shutting it off by hand.

This alarm can be adjusted while pressure is on the boiler, hence the left-hand

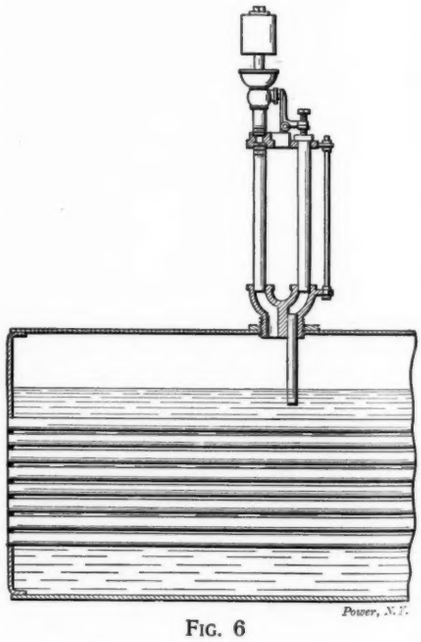


FIG. 6

pipe is then as hot as steam can make it; consequently, it makes no difference whether it is made of iron or brass, because its length when expanded becomes the standard regardless of the amount of expansion. The right-hand pipe must be filled with cool water when the adjustment is made, and as soon as it is expanded by steam the whistle blows (if a correct adjustment has been made) regardless of the length of the left-hand pipe, hence it is plain that the difference in expansion has no bearing on the device or its operation. A reinforcing ring is riveted to the shell in order to afford a more secure fastening for the alarm, and this is worthy of adoption in all such cases.

One advantage of low-water alarms operated by the expansion of metal is that they can be tested at any time and their condition proved beyond dispute. The only disadvantage is that they require

fine adjustment, which is too difficult a task for the ordinary fireman or water tender to complete and maintain; but, on the other hand, there seems to be no good reason why the engineer should not attend to this exclusively, and thus avoid all trouble along this line.

The low-water alarm illustrated in Fig. 7 consists of a whistle screwed into the shell, containing a lever valve operated by a float which rises and falls with the water level. This arrangement will undoubtedly work well as long as the float remains in good order, but unless it is of superior design and made in a more workmanship manner than many of those found in service, it will prove a source of more worry and vexation than of comfort.

A dishonest boiler attendant cannot tamper with this low-water alarm while it is in service, as the float is in a secure place, and there is no globe valve on the outside to close, in order to prevent exposure of carelessness in allowing the water level to fall too low for safety.

The disadvantages of this device are that if the float collapses or fills with water and sinks while there is still plenty of water in the boiler, the whistle will blow and no legitimate way of stopping it is provided. Such defects, or a failure of the lever mechanism, cannot be repaired easily, as the boiler must be laid off for this purpose, and if this is not practicable, the low-water alarm must be dispensed with until an opportunity arrives for entering the boiler and making necessary repairs.

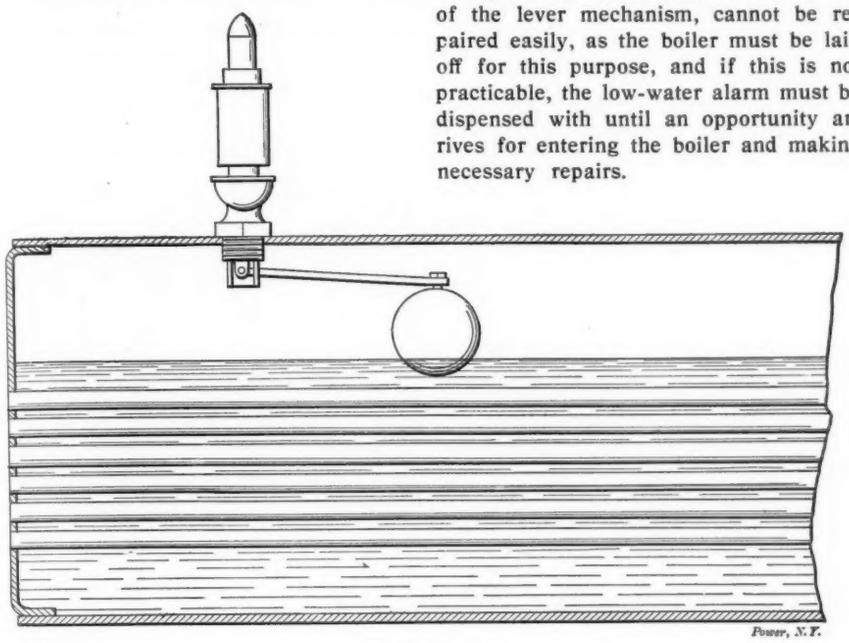


FIG. 7

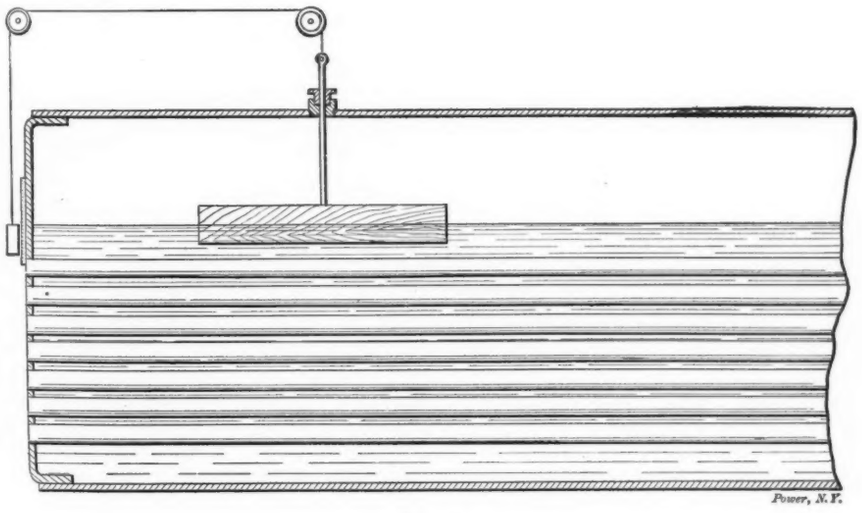


FIG. 8

Fig. 8 shows what may be called a "homemade" low-water indicator. It consists of a block of wood floating on the water to which is attached a brass rod carried through a stuffing box in the shell. A stout cord or an annealed wire is carried from this over two pulleys and supports a weight suspended in front of a dial, and the position of this weight indicates the water level. This device was described to me by an English engineer who had used it.

Fig. 9 illustrates a low-water alarm that is not attached directly to the boiler but to the water column. The lower connection is made by removing the first gage cock and screwing in a close nipple followed by a tee, the outer end of which receives the gage cock for use as before. Into the side outlet of this tee a close nipple is screwed, followed by an ell and other connections as shown. The upper connection is made by removing the third gage cock and proceeding as before, using brass pipe and fittings because they rust and corrode less than iron.

While there is one gage, or more, of water in the boiler, the standpipe remains full of comparatively cool water, but when the water level falls until there is only about one inch left in the glass, steam enters the standpipe and as it is made of copper it lengthens, thus opening the whistle valve by means of the rod shown, and admitting steam from the third gage cock through a cross passage to the whistle, although water comes first, as a small amount always stands in the vertical pipe which stands parallel to the standpipe.

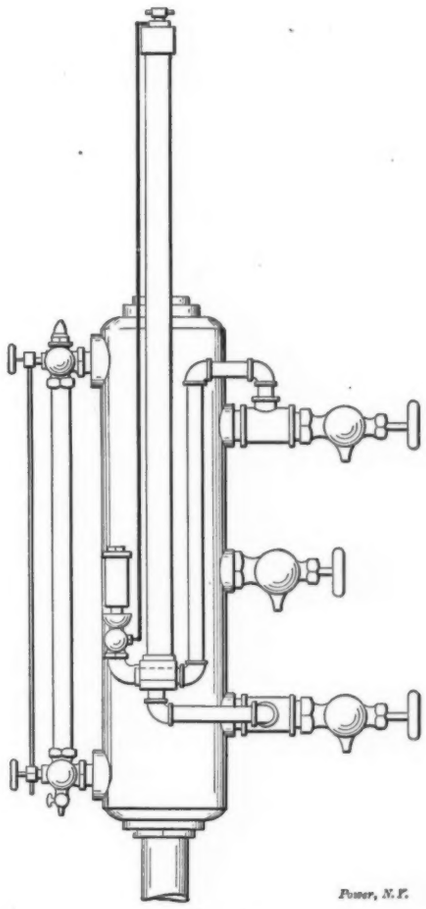


FIG. 9

Fig. 10 is an independent water column to be used as a low-water alarm. It contains a steel float to secure the required strength and it is coated with copper to prevent corrosion. A water gage and three gage cocks can be tapped into this

column if desired. It is a very simple device, for as long as there is water enough to keep the float in its highest position, the whistle is silent, but when it falls and lowers the float, the alarm is given with no uncertain sound. It can be tested at any time by opening the drip valve.

The whistle and the float are connected to the body of the water column, hence when repairs are necessary the cap

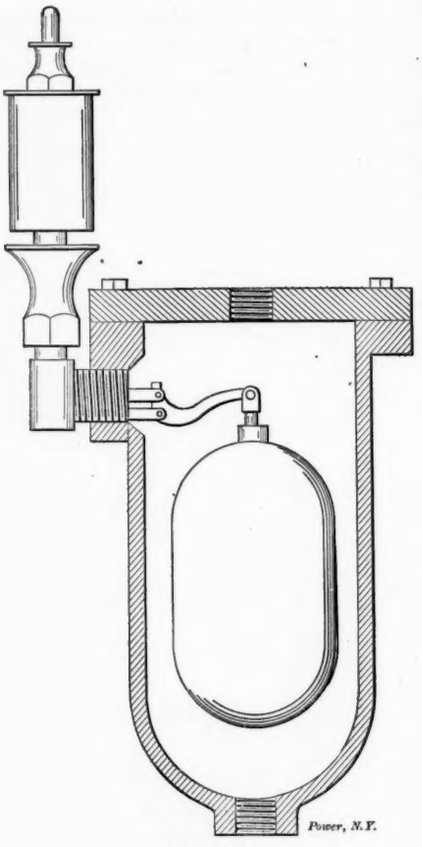


FIG. 10

screws shown are removed and a union in the pipe below is disconnected, thus leaving the column free to be moved sidewise and taken down. The same packing can be used several times if one side of it is coated with graphite. After repairs are completed the column can be returned without disturbing the piping. The cap of this column is flat, therefore any ordinary wrench can be used to tighten the cap screws without inconvenience, which is a valuable feature. Special care should be taken when installing this or any other water column to set it high enough to give an alarm when there is at least 4 inches above the tubes, flues or crown sheet.

Fig. 11 resembles the preceding, but is much longer, hence is suitable for boilers in which the water level may vary to a greater extent without causing damage, as the extreme length of this column is nearly 5 feet. The float is in the form of a sphere, which is the strongest that can be devised. In this case the whistle and its controlling mechanism are attached to the cap, hence when this is removed all the working parts come out with it. This is a very convenient plan when it is practicable to run the pipe connection directly into the body, as shown by the larger tapped holes, but there are many cases in which it is better to make connections into the top and bottom, thus making it impossible to lift the cap out as described, unless a union is used in the piping, which would otherwise be unnecessary.

Fig. 12 illustrates another low-water alarm in which the controlling mechanism is attached to the cap. This does not include a float, hence there is no danger of it collapsing or filling with water. One large gravity weight on the end of a rod and a small solid weight on one of the compound levers operate to open and close the whistle valve, according to the hight of water in the boiler and hence in the column. When there are two gages of water, the larger weight so nearly floats that the small one is sufficient to counterbalance it and keep the whistle valve closed, but when the water level

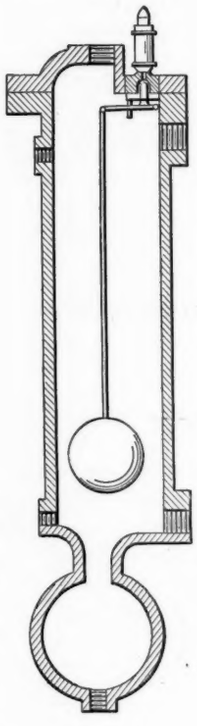


FIG. 11

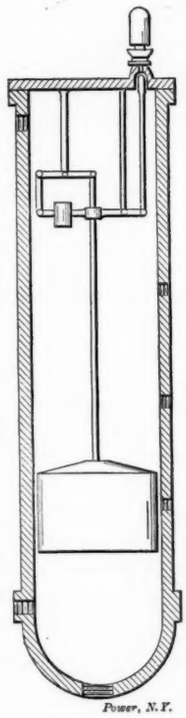


FIG. 12

falls, leaving one free, it opens the whistle valve and sounds an alarm.

Fig. 13 is similar to the foregoing, but the compound levers are dispensed with, and only one used instead, consequently the upper solid weight is larger, but the device is simple and not liable to get out of order.

Many boilers have been seriously damaged, some of them beyond repair, by allowing water to get low in them with a brisk fire in the furnace, and others have suffered from the effects of fire under them before they were filled at all, yet only a comparatively few explosions have occurred directly from this cause, and there is no mystery about any of them. If a plate or a crown sheet is red hot from lack of water, its original strength is greatly reduced, hence the ordinary working pressure may cause it to fail, and it may not have sufficient strength to destroy much property, for it is plain that a weak boiler will rupture

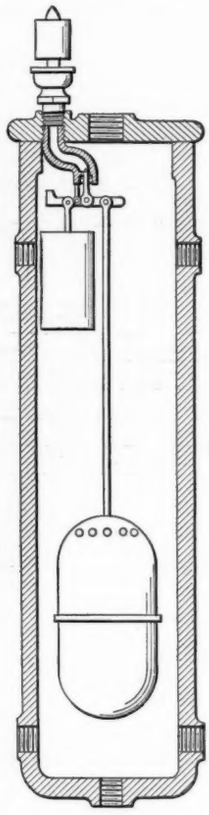


FIG. 13

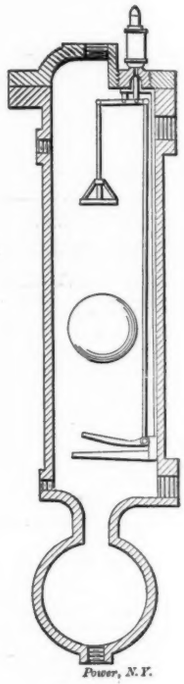


FIG. 14

before a high pressure can be secured, hence the resulting damage will be light.

Furthermore, the overheated part may fail just as more water is pumped in, but it is doubtful if the entrance of water into an overheated boiler has ever caused the instantaneous increase of pressure with which it is charged, or resulted in the formation of a mysterious gas that could not be controlled. Experiments that have been made under working conditions to prove the truth of claims made for the aforementioned destructive agents have failed to show that we are in danger from them.

There can be no doubt about the truth of claims made for excessive repair bills, damaged boilers and expensive delays to business caused by failures to keep boilers properly supplied with water, and these are sufficient to warrant every precaution that can be taken to prevent such accidents without causing them to appear mysterious, or uncontrollable. The variety of low-water alarms already described and illustrated in these pages, and the large numbers of them sold and

put into service on various kinds of boiler, furnish proof of their need and value.

Previous illustrations are of devices that guard against low water only, but very expensive accidents have happened on account of high water in boilers, because under such conditions there is danger of delivering hot water to the engines instead of steam, and as they are not built for such abuse the weakest parts must fail, and although such accidents seldom result in loss of life, they destroy valuable machinery and cause delays to business.

Fig. 14 illustrates a water column fitted with an alarm for both high and low water, which operates as follows: A spherical, seamless float without means for attaching a lever or rod to it is put into the column, which is then partly filled with water to secure working conditions. The float stays on the surface or is only partly submerged, bringing it into the position shown. The upper weight is sufficient to keep the whistle valve closed, but if the water level is raised higher than good practice admits, the float comes in contact with the upper weight, raises it and blows the whistle. If the supply of water to the boiler is shut off and the process of evaporation is continued, the float is lowered with the water level until it rests on the lower lever shown, and this action blows the whistle. As the float is not fastened to anything, it is free to turn in every direction, hence it cannot wear excessively in one place; therefore, it proves durable in practice. All of the mechanism is fastened to the cap, hence when this is removed the internal parts come out with it.

Inspection for Locomotive Boilers

By Herman B. Walker

Renewed efforts will be made to secure the passage by Congress this year of a law for a Federal inspection of locomotive boilers. The bill introduced by Senator Burkett, of Nebraska, for this purpose, is entitled "A bill to promote the safety of employees and travelers upon railroads by compelling common carriers by railroad to equip their locomotives with safe and suitable boilers and appurtenances thereto." The same bill was introduced by Senator Burkett two years ago, but was smothered in committee. His bill this year has been referred to the same committee, that on interstate commerce, of which Senator Elkins, of West Virginia, is chairman, and the Brotherhood of Locomotive Engineers, the Federation of Labor and other organizations interested in the measure, will make a desperate effort to have the bill reported from committee and acted on in the Senate.

The sort of locomotive-boiler inspection proposed in the Burkett bill is identical with the steamboat-boiler inspection provided by the Federal Government, which has been tightened up and extended since the "Slocum" disaster until it includes a rigid supervision of steamboat boilers of all kinds used in interstate commerce. Thirteen States now provide by law for some kind of locomotive-boiler inspection, but these State laws vary in scope and effectiveness, are more or less laxly enforced, and because of their differing requirements, added to the fact that in the remaining 34 States there is no inspection, the result is that comparatively few of the boilers used in railroad locomotives come under any sort of official supervision or inspection.

In the five years ending with 1908, there were 249 persons killed and 670 injured in locomotive-boiler explosions in the United States, according to the reports of the Interstate Commerce Commission. Some sort of systematic and effective boiler inspection under Federal authority, it is urged by the advocates of the Burkett bill, would largely reduce if not wholly prevent this annually increasing large number of accidents and casualties. The details of the casualties resulting from locomotive-boiler explosions in the five years, as given by the Interstate Commerce Commission, are as follows:

Year.	Trainmen.		Other Employees.		Passengers.		Total.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
1904	42	129	1	4	0	0	43	133
1905	36	109	9	15	0	5	45	129
1906	38	119	1	7	0	1	39	127
1907	73	144	5	16	0	5	78	165
1908	42	101	2	15	0	0	44	116
Totals	231	602	18	57	0	11	249	670

The Burkett bill would make it unlawful for any common carrier engaged in interstate or foreign commerce by railroad to use a locomotive the boiler of which was not equipped with a steam-pressure gage, safety valve, gage cocks or try cocks, a water glass showing the hight of the water in such boiler, and having a shutoff cock, or shutoff valve, at each end of such glass, all such cocks and valves to be so constructed and maintained that they can be easily opened and closed by hand; or to use any locomotive the boiler and appurtenances of which did not comply with the following requirements: the boiler to withstand a hydrostatic test, in the ratio of 150 pounds to the square inch to 100 pounds to the square inch of the working steam pressure allowed; the boiler and appurtenances to be made of good and suitable materials; the openings for the passage of water and steam, respectively, and all pipes and tubes exposed to heat to be of proper dimensions and free from obstructions; the spaces between and around the flues to be sufficient; the boiler, flues, safety valves, fusible plugs, low-water indicators, feed-water apparatus, gage cocks, steam gage, water and steam pipes, low-water gages, means of moving mud and sediment from boiler, and all other machinery and appurtenances to be of such construction, shape, condition, arrangement and material that they might be safely employed in active service without imperiling life and limb.

The actual inspection of locomotive boilers would be made under the direction of the Secretary of Commerce and Labor, and every boiler and other appurtenances of every locomotive used in interstate traffic would be subject to inspection at least once in three months. A certificate of inspection would be furnished at each inspection, to the engineer operating the locomotive, and it would be unlawful to operate a locomotive which did not have a certificate of proper date framed under glass in the cab of the locomotive. If an inspector found a locomotive which he did not consider to meet the requirements of the law, or which might, in his opinion, be unsafe to life or limb in operation, it would be his duty to give to the operator of the locomotive his reasons in writing for so believing, and it would then be unlawful for the carrier owning the locomotive to use it in interstate traffic until it had been repaired or remodeled, and upon another inspection found to meet the requirements of the law.

Persons to be appointed as inspectors of locomotive boilers, under the act, must have been practical boilermakers of at least four years' experience in the construction and repair of locomotive steam boilers, of good character and good qualifications and attainments, and who, from their knowledge and experience, must be able to form a reliable opinion of the strength, form, workmanship and suitableness of locomotive steam boilers.

ELECTRICAL DEPARTMENT

Especially conducted to be of Interest and Service to the men in charge of the Electrical Equipment

Electric Elevators

By William Baxter, Jr.

There are some points in regard to the operating principles of electric elevators that should be perfectly understood by anyone who desires to become thoroughly familiar with the operation of such machines. These points are explained in the present and the succeeding articles.

Fig. 86 is a very simple diagram of an electric elevator of the drum type with the hoisting machine located at the top of the elevator well. The sketch shows a counterbalance weight but this is not actually necessary; it is used to save power, and also to make the elevator safer. From a purely theoretical view, it is not necessary to provide the counterbalance to save power, because the car when running down could be made to return a large portion of the energy that was absorbed in raising it. With a shunt-wound direct-current motor it is very easy to accomplish this result, because such motors will act as generators when driven somewhat faster than normal speed. The energy recovered in this way, however, cannot very well be more than 40 per cent. of that used to raise the elevator, because of the friction of the worm gear of the elevator machine. Even this comparatively small amount of energy cannot be fully utilized because it will not be recovered at the time when it can be used to the best advantage.

If there were several hundred elevators running on a circuit, and these averaged about one-half on up trips and the other half on down trips, then the net power generated by the motors of the descending elevators could be utilized in driving the motors of the ascending cars, and the generators at the station would only have to supply the difference. In practice, however, there are generally not many elevators running on a circuit and these are not likely to be equally divided between the up and down trips, so that in some cases when there were only a few cars coming down the power their motors would generate would be of very little assistance to the generators in the station. If the conditions were reversed so that nearly all the cars were coming down, the power generated might be more than those going up could utilize.

It has been proposed to arrange elevators so that each motor may utilize on the upward trips the power developed on the down trips, which can be accomplished by providing storage batteries to be charged on the down trips. But such an arrangement would be complicated and could not be used unless it possessed other advantages sufficient to overbalance the objections. The principal objection to such a system is that even under the most favorable conditions it cannot be as efficient as elevators using counterbalance weights, and the only gain to offset this is that the counterbalances and their guides can be dispensed with; and this is really no gain, because these parts are not as expensive to install or keep up as the storage batteries, and do not take up as much valuable space. For these reasons wholly unbalanced electric elevators are not used.

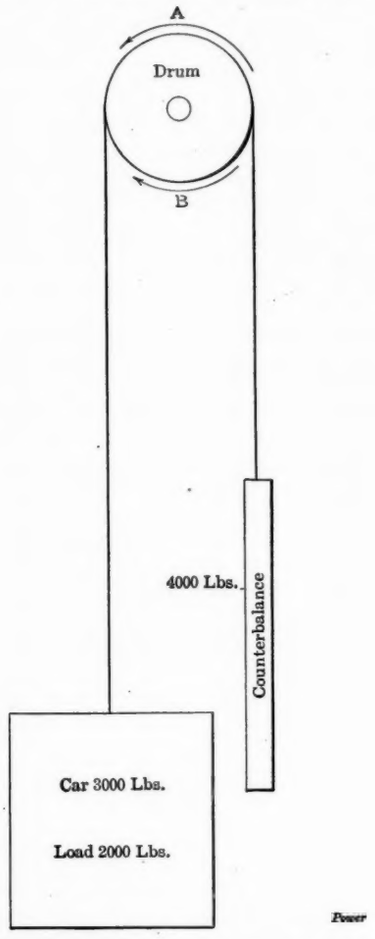


Fig. 86. Elevator Counterbalance

Balanced elevators are sometimes made so that the counterbalance weighs considerably less than the empty car, but the present almost universal practice is to make the counterbalance heavier than the empty car, the excess of weight ranging from about one-fifth to one-half of the maximum load the elevator is designed to lift. The efficiency of the overbalanced elevators is higher than that of those that are underbalanced; the highest efficiency is obtained in any case when the overbalance is equal to the weight of the load carried by the elevator. Probably the average load in the great majority of cases is about two-fifths of the maximum load, so that if an elevator is designed to lift a maximum load of 2500 pounds, the overbalance should be 1000 pounds to give the highest all-day efficiency. To be able to lift the greatest maximum load with a motor of a given size, the overbalance should be equal to one-half the maximum load.

If the counterbalance is considerably lighter than the empty car, it is much easier to stop the car accurately at the floors of the building than otherwise. The deficiency in weight must be such that the empty car will run down by gravity. Suppose that in Fig. 86 the counterbalance weighed 2500 pounds, and that the excess of weight of 500 pounds in the car were sufficient to overcome all the friction of the apparatus, then if the empty car were started on a down trip it would continue to descend and the motor would have to do no work. With any load in the car the power developed by its descent would be more than necessary to run the car at the normal velocity and to prevent it from attaining too high a speed a retarding influence would need to be introduced. The greater the load in car the greater the excess of power and the greater the retarding influence required to prevent the speed of descent from becoming too great. The retarding influence required in such cases is developed by the motor itself, in a way that will be presently explained, and the action is entirely automatic so that the retarding effect at all times is just enough to keep the car speed at the right point.

From the foregoing it is clear that if the weight of the empty car exceeds that of the counterbalance by an amount that is enough to drive the elevator mechanism and run the car down, the motor will not have to do any work on any down trip, but on the upward trips the motor will always have to do work, for even when the car is empty sufficient power will have to be applied to raise the 500 pounds of unbalanced weight and

overcome all the friction of the elevator apparatus in addition.

Under such conditions the problem of providing a controller that will stop the car automatically at the top and bottom of the elevator well, level with the floors of the building, is not very difficult, because it will have to act the same on all trips in the same direction. To make a controller that would stop the car level with each floor under all conditions of load would be a very difficult matter, even when the counterbalance is lighter than the car; but such perfection of operation is not necessary. If the automatic stopping apparatus is adjusted so that the car will stop flush with the floor with an average load in the car, the result will be that when running up with a full load the car will stop a few inches short of the floor, and if the load is light it will run a few inches too high. On the down trips the car will overrun the mark by a few inches when carrying a heavy load, and stop short of the floor if the load is light.

When the car is overcounterbalanced the difficulty of providing a controller that will make accurate stops automatically at the top and bottom floors is greatly increased owing to the fact that the controller cannot act the same way on all the trips in the same direction. This statement applies, however, only to high-speed elevators. When the car speed is low, it is as easy to make a controller for an overbalanced elevator as for one that is underbalanced, owing to the fact that the distance in which the car can be stopped is so short that any difference in the action due to light or heavy loads will only cause the car to stop an inch or so out of the way.

An operator who uses reasonably good judgment can prevent a car from running above the top floor when the load is light and it is stopped by the automatic stop. To accomplish this all that is necessary is to move the car lever to the stop position when the car is within about one floor, or a trifle more, of the upper landing, and then turn the lever again to the running position. If the car is running up with a full load all that can be done to cause it to run up to the floor level before stopping is to let it run up at full speed.

When the car is stopped at the lower floor by the automatic stop, it will run below the floor if the load is great, and stop short if it is light, and to avoid this as far as possible, the speed should be checked when the load is heavy, and should be kept up to the highest point if the load is light. As a rule there is no great difference in the stopping position of the car at the top and bottom floors, when stopped by the automatic stops owing to the fact that generally the car reaches these floors with about the same load; that is, on all up trips the load that reaches the top floor is about the same, and this is also true of the bottom floor on the down trips. When the car is coming down to the lower floor with an extra-large load, a careful operator will not depend upon the automatic stop, but will stop the car himself, by means of the car lever, and with corresponding caution, he will not let it run up to the top floor at full speed if the load is unusually light.

Primer of Electricity

The connections of an ordinary armature are complicated to a beginner, so it will be better, perhaps, to lead up to the actual arrangement gradually by adding to the simple one-coil armature a little at a time. Then suppose that instead of one loop the armature had two coils of four turns each, arranged at right angles to each other, as represented in Fig.31, and connected to the two commutator segments as shown in Fig. 32, where each coil of four turns is represented by two dots on opposite edges of the armature core. In the position shown, the coil *A A'* is passing from pole to pole, and is short-circuited at the commutator by the brushes touching both segments at the same time; the coil is generating no electromotive force at this instant. The coil *B B'*, however, is also short-circuited, and as it is generating its full e.m.f., this short-circuit would cause an excessive current to flow in the coil for the instant. However, ignore this

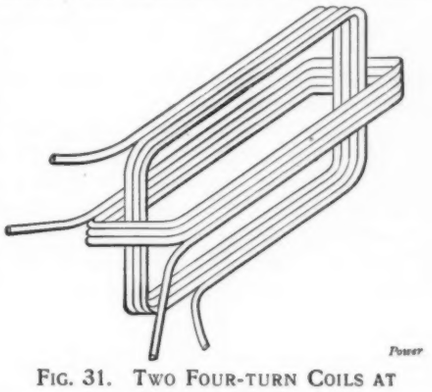


FIG. 31. TWO FOUR-TURN COILS AT RIGHT ANGLES

for the present. When the coil *A A'* has passed the short-circuited position and begins generating an e.m.f. by passing the magnet poles, it will be connected in parallel with the coil *B B'*, as shown in Fig. 33, where both coils are active. Following the connections, it is evident that as the wire *A* and the wire *B'* are both connected to the commutator segment *a*, and the wires *A'* and *B* are both connected to the segment *b*, their relations are as shown by the diagram, Fig. 34. Their induced electromotive forces are in opposition when they reach the commutator, and they therefore do not force current through each other,

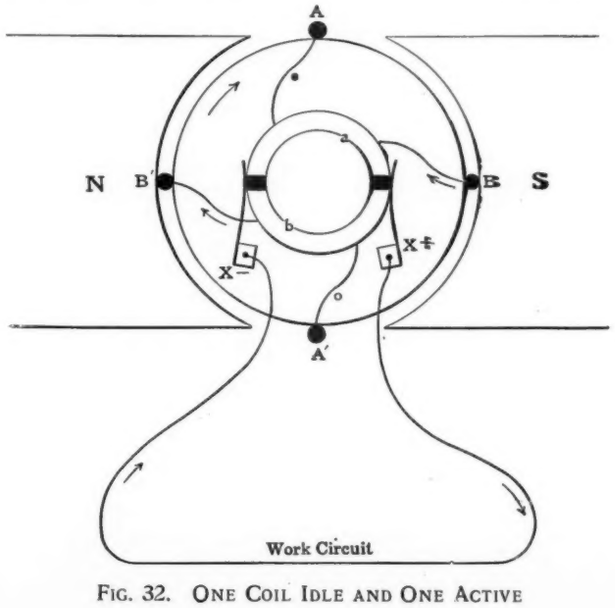


FIG. 32. ONE COIL IDLE AND ONE ACTIVE

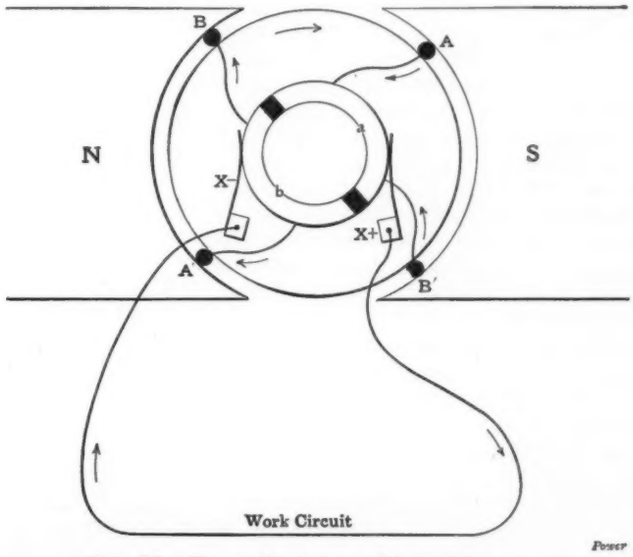


FIG. 33. BOTH ARMATURE COILS ACTIVE

but join in forcing it out through the external circuit. If the current in the outside circuit is 10 amperes, for example, 5 amperes of it will come from

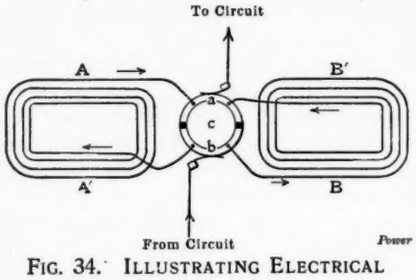


FIG. 34. ILLUSTRATING ELECTRICAL RELATIONS OF COILS IN FIG. 33

each coil, the two currents joining in parallel at the brushes.

This condition of equality between the e.m.f. induced in the two coils exists only for a short time during each quarter revolution; that is, when the coils are in the position shown in Fig. 33, and when the armature has turned one-quarter of a revolution, one-half of a revolution while generating unequal electromotive forces are avoided. The connections between the coils and the commutator look confusing at first glance, but if the reader will take the time and trouble to follow them through, the confusion will disappear, because every coil is connected to the commutator just like every other coil. The ends, or, more properly speaking, the *terminals* of each coil are carried to adjacent commutator segments; consequently, when the pair of segments belonging to any coil pass under one of the brushes, that coil is short-circuited for an instant, but when this happens the coil is midway between the magnet poles and not generating any e.m.f. Referring to Fig. 35, the coil $A\,A'$ is shown near the middle of the interpolar space and the two commutator segments to which it is connected are short-circuited by the brush $X-$; similarly, the coil $E\,E'$ is in the inactive part of its travel and the two commutator segments to which its terminals are connected are short-circuited by the

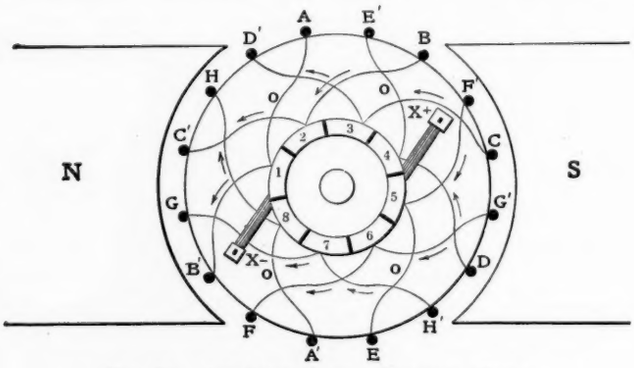


FIG. 35. AN EIGHT-COIL WINDING; COILS *A* AND *E* INACTIVE

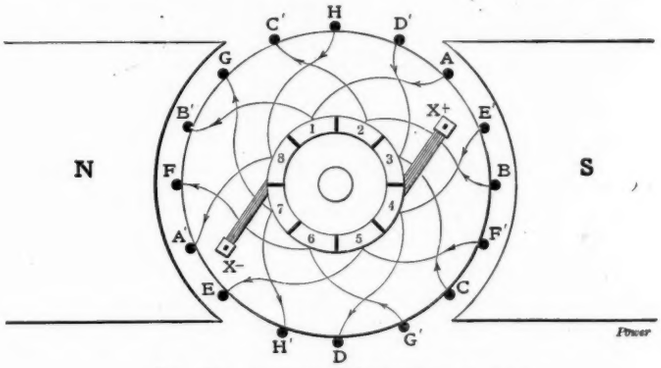


FIG. 36. ANOTHER POSITION OF THE EIGHT-COIL ARMATURE*

and comparison with Fig. 36 will show that the direction of the current through each part of the winding as stated in the above tabulation corresponds with that indicated by the arrows in the diagram. It should be noted also that these arrows show that the current in all wires passing the south poleface flow from

and three-quarters of a revolution from that position—four times during each complete revolution. In all other positions, one coil will have a higher e.m.f. than the other because it will be cutting magnetic lines of force faster (passing through a denser part of the field, though at the same speed, will cause it to cut a greater number of lines per second), and the coil having the higher pressure will force some current backward through the other coil. For example, if the coil *A* were generating 20 volts while the coil *B* generated 19 volts, a back current would flow from *A* through *B* equal to the difference in pressure, 1 volt, divided by the resistance of the coil *B*.

Because of this disadvantage, and also because of other objectionable features of a two-coil armature, more coils are necessary.

In Fig. 35 is shown an armature having eight coils and eight commutator segments. With this arrangement both the disadvantage of short-circuiting a coil while it is passing a magnet pole face and that of having coils in parallel

brush $X+$. All of the other coils are carrying current and they are connected in two parallel groups, each group consisting of three coils in series. Thus, starting at the brush $X-$, taking the lead going to the coil-side B' and following through the winding, the path is

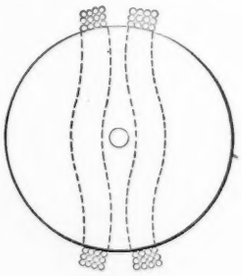


FIG. 37

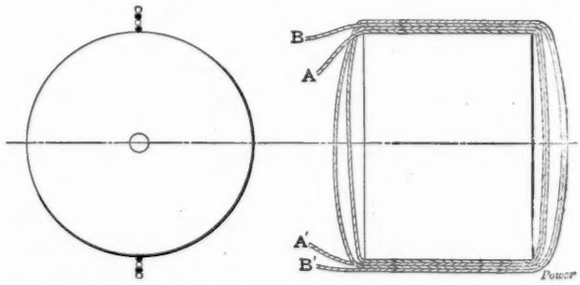


FIG. 38. ELEMENT OF A TWO-COURSE WINDING

through the coil $B'B$ to the segment 2, the coil $C'C$ to the segment 3; through the coil $D'D$ to the segment 4, and out to the circuit through the brush $X+$; going back to the brush $X-$ again, take the other lead, from the segment 8 to the coil $H\,H'$, through that coil to the segment 7, through the coil $G\,G'$ to the segment 6; through the coil $F\,F'$ to the segment 5 and through the brush $X+$ to the outside circuit. From this it will be evident that the coils *B*, *C* and *D* are in series with each other and this series group is in parallel with the coils *F*, *G* and *H*, which are in series with each other.

Fig. 36 shows the condition of things after the coils *A* and *E* get past the short-circuited position, and this diagram, together with the following table, will explain how all the electromotive forces of the different coils are in the right direction to avoid unequal opposition between two coils and to make the currents flow in the proper relative directions to combine at the brushes and pass out to the circuit and back to the armature winding. Starting at the brush $X-$ the two paths through the winding are as follows:

$$X- \text{ to } \left\{ \begin{matrix} GG', 6, FF', 5, EE', 4, DD', 3, \\ H'H, 8, A'A, 1, B'B, 2, C'C, 3, \end{matrix} \right\} \text{ to } X+,$$

back to front of the armature and from the winding to the commutator, while the currents in all wires passing the north poleface flow from front to back of the armature and from the commu-

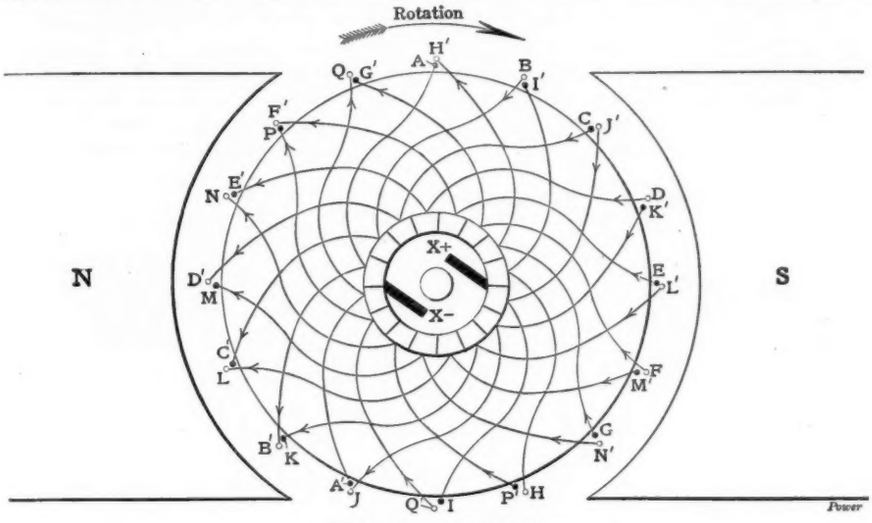
*By an engraver's error the brushes are shown touching two commutator bars each. They should be resting on bars 7 and 3 only.

tator to the winding. This illustrates the rule:

The current induced in any wire on an armature revolving clockwise flows away from the observer when the wire passes a north pole and toward the observer when the wire passes a south pole.

In Figs. 35 and 36 the winding is represented as being arranged in a single layer around the periphery of the armature core. This is done only in armatures which are intended to generate a very low electromotive force. When any of the standard voltages used for lighting and power purposes are generated the winding is arranged in two or more layers. In small machines each armature coil contains several turns—eight, ten, even twenty and thirty in very small machines. In such cases the wires of a coil form several layers and there are several wires side by side also, as indicated in Fig. 37, where a single coil of 12 turns is shown on a core, the wires being shown as though cut off at the end of the core. In almost all cases, the winding is divided into two general layers, half of one coil lying on top of half of another one. Fig. 38 illustrates this arrangement for two coils of two turns each. Such a winding is called a *two-course* winding, the layers of the bottom coils being one "course" and those of the top coils the other "course." In Fig. 38 the wires are striped spirally, with the spirals on adjacent wires opposed for convenience in tracing the wires; also, the wires are shown widely separated where they cross the ends of the armature core, but in practice they are laid as flat and close to the core as practical. Tracing the wire of the coil *A* it will be found that all of its turns are inside those of the coil *B*; the former, therefore, is in the inner "course" and the latter in the outer "course" of the winding.

Fig. 39 is a diagram of a two-course winding in which each course contains only one layer and each coil one turn. The similarity between this and the winding in Figs. 35 and 36 will be apparent upon comparing the commutator connections. The system of connections is the same but this is a two-course winding of 16 coils and Fig. 35 shows a one-course winding of 8 coils. The commutator and brushes are drawn as though the commutator were clear on the inside and the brushes resting against the inner surface. This is done to avoid complicating the diagram by "mixing up" the brushes and the armature connections. In following the course of the current through the winding it will be found that it goes through the coils of the inner and outer courses alternately; after passing through a coil in the inner course, the next coil will be found in the outer course. For convenience in distinguishing the courses, the wires in the outer course are represented by circles and those in the inner course by dots.



Paths through winding:

$X-$ to $\left\{ \begin{matrix} B'B;\ c;\ C'C;\ c;\ D'D;\ c;\ E'E;\ c;\ F'F;\ c;\ G'G;\ c;\ H'H;\ c \\ QQ';\ c;\ PP';\ c;\ NN';\ c;\ MM';\ c;\ LL';\ c;\ KK';\ c;\ JJ';\ c \end{matrix} \right\}$ to $X+$

Coils AA' and II' short-circuited by brushes.

"c" means commutator.

FIG. 39. A TWO-COURSE WINDING OF 16 COILS

CORRESPONDENCE

The Crown of a Dynamo Pulley

In the days when generators were driven by belts from a main shaft, all went well until it was attempted to run alternators in parallel. I thought there could be no trouble and made the attempt, in both cases allowing 2½ per cent. for belt slippage, but did not succeed. I then proceeded to investigate and found the pulleys were not alike, and following the subject further found that the practice in turning pulleys was to keep the cutting tool going until there was a good surface, and put any old crown on it.

Then came the question: If the crown on the dynamo pulley has one slope and that on the shaft pulley has another, what governs the speed, the diameter of the crown or that at the edges of the pulley? Furthermore, with different crowns must there not be more slip on one pulley than on the other?

I then had pulleys made under specifications which stipulated that when they arrived they would be measured by a steel tape around each edge of the pulley and the size, thus measured, must be exactly as ordered; further, that the pulleys should be crowned ⅛ inch per foot width of pulley face. All pulleys not meeting these requirements were to be returned at the expense of the maker.

The dynamos ran in parallel but the belts "floated" all over the faces of the pulleys and the slight crown was not sufficient to keep the belts running straight on the pulleys. The face might as well have been flat.

After this I changed my specifications to ¼ inch slope per foot of face width, and the belts ran all right.

I recently had a case where the engine was belted direct to the generator. The ¼-inch crown slope was called for in this case. The generator pulley had a face of 25 inches and the engine pulley 32 inches. The belt ran back past the cylinders and to avoid cutting out an important beam in the building an idler was put under the slack side of the belt to carry it over this beam. This idler was so constructed that the shaft could be set level or with either end tilted upward; either end could also be shifted in either direction, and it seemed as though the belt could be guided in any direction.

The engine pulley, contrary to directions, was crowned ⅛ inch to the foot and the belt seemed to be determined to run on one edge of the pulley; it did not care which side, but would not run in the center. When it was running on one side, swinging the idler to bring it into the center would make it float over onto the other side. The pulley was then crowned as ordered and the belt ran better, and when the load was put on it was all right.

Belts in many cases will run on straight faces all right, also on crowns of ⅛ inch to the foot; there will not be much difference between the two. To have much influence, the crown requires more slope.

W. E. CRANE.

Duluth, Minn.

GAS · POWER DEPARTMENT ·

Everything worth while in the Gas Engine and Producer Industry will be treated here for the use of practical men

A 2000 Horsepower Single Cylinder Engine

The remarkable feat of developing 2000 horsepower in a gas engine having only one cylinder has been accomplished by the Siegen Machine Works, Siegen, Germany, according to *Engineering*. The engine is of the Körting double-acting type, working on the two-stroke cycle, and is used for blowing purposes in a steel works. Figs. 3 and 4 show an elevation and a plan view of the engine and its blowing "tub." The stroke is 1400 millimeters (55⅛ inches) and the power cylinder bore is 1100 millimeters (43.3 inches) in diameter. The blowing cylinder bore is 2550 millimeters (100.39 inches) and the maximum speed of the unit is 90 revolutions per minute.

When starting up, the engine is relieved of load by opening a connection between the blowing cylinder and the suction. This connection consists of Corliss type valves, which are fitted in the blowing heads and are actuated by small hydraulic rams bolted to the engine bed. As soon as the engine has started, the valves are closed, and instead of blowing back to the suction, the engine then delivers air into the blast main. They may also serve another purpose if at any time, for instance, it be necessary to blow at an abnormally high pressure. In such a case one side of the blowing cylinder may be left permanently open to the suction, while the other blows at the required pressure. This, however, would be necessary only under exceptional circumstances.

The general design of the engine is clearly shown by Figs. 3 and 4. The connecting-rod big end is of special interest; it will be noted that there are no long bolts in it. This design is peculiar to the Siegen company, and has proved to be both convenient and very strong, although, perhaps, a little more expensive than usual in manufacture. The main beds run through from back to front of the engine, and are held together by means of wrought-iron shrunk rings. The cylinders rest on these beds with the plane of the feet at the level of the center line of the engine.

The building of an engine of this size with a single power cylinder formed an important departure. Although there were many difficulties to be overcome, it was found possible to adhere fairly closely to the standard design of the company. Perhaps one of the most important details to be attended to was the design of the large inlet valves; these had, of course, to be made so as to run as silently as possible. Fig. 2 shows their design and the gear for operating them. The valves are of steel, 500 millimeters (19.68 inches) in diameter at the seat; they have a lift of 80 millimeters (3.14 inches), and are able to run at a speed of 90 strokes per minute without noise. They are opened by means of pull rods coupled to cranks on the side shaft; eccentrics proved to be too unwieldy for the required stroke. The two cranks are set at 180 degrees to each other. The movement is imparted to the valve by means of rolling or wiper-cam levers, the bottom one of which transmits motion to the spindle through a sliding jaw. A spring alone was not considered to be sufficient to close the valve and a vacuum piston was therefore provided above the valve, which not only assists the valve in closing, owing to the vacuum formed at the top of it, but also balances the pressure exerted on it by the pumps, and insures silent closing. This design has proved to be thoroughly efficient, and absolute quietness has been obtained.

In order to be able to vary the setting of the inlet valves with respect to the main crank, a somewhat novel adjustable coupling has been introduced into the valve-gear shaft between the main bevel-wheel drive and the valve gearing. This is shown in Fig. 1. The left-hand half coupling is keyed solidly to the shaft, while the right-hand half may be slid back along a feather key. In the faces of the two halves there are ridges cut in the form of radial teeth, having a pitch of ⅛ inch at the outside diameter. By means of these teeth the two halves grip each other. Two encircling rings *A* and *B* are provided for holding the two inner half couplings tight together. By slacking the bolts through these rings, sliding the right-hand half back on the shaft, turning the valve-

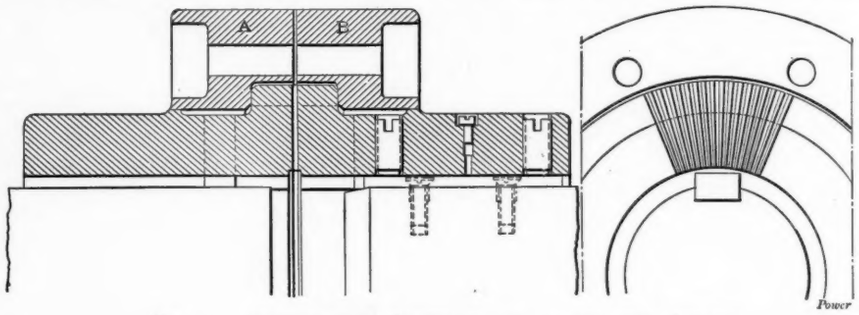


FIG. 1. ADJUSTMENT COUPLING ON VALVE-GEAR SHAFT

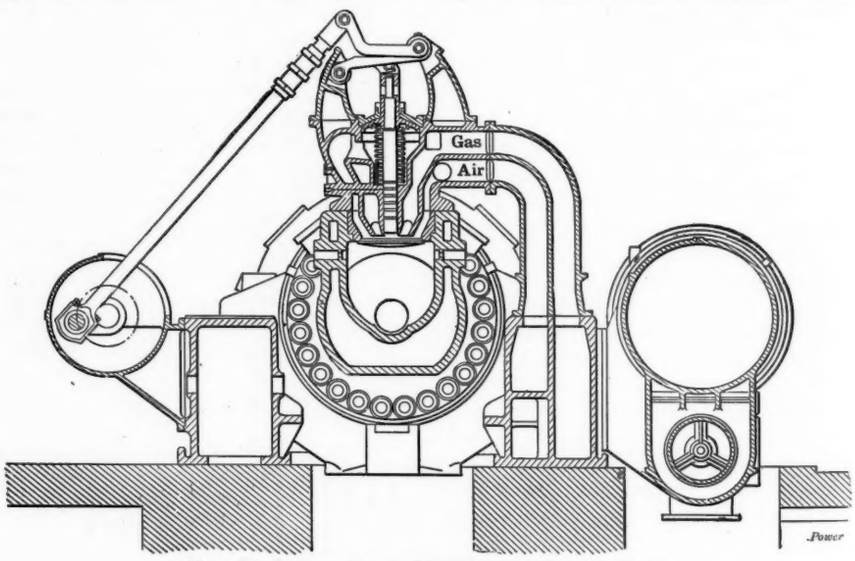
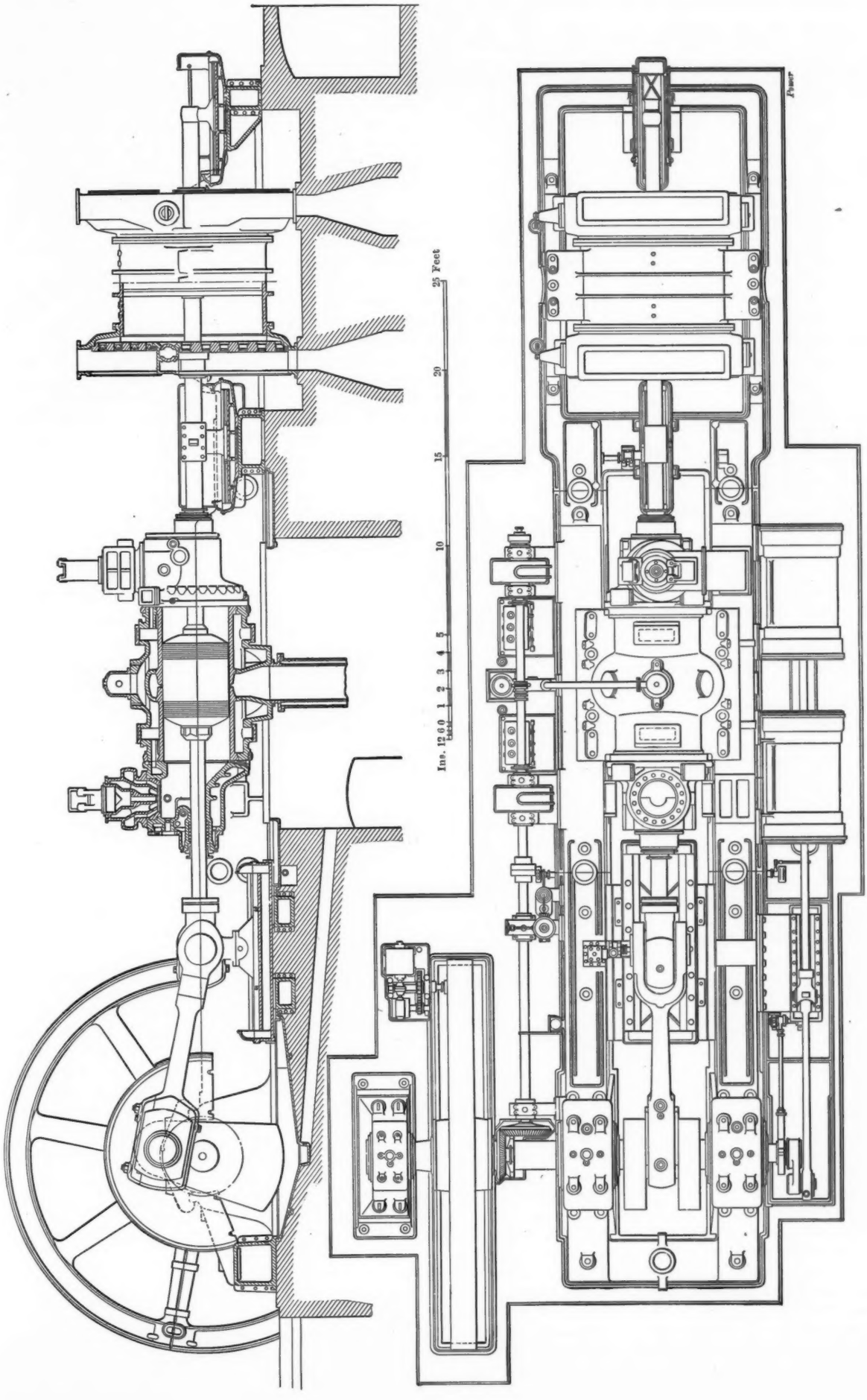


FIG. 2. LARGE INLET VALVE AND VALVE GEAR



FIGS. 3 AND 4. SECTIONAL ELEVATION AND PLAN VIEW OF ENGINE

gear end of the shaft, and again bolting up tight, a variation of the setting of as little as 1 degree may be obtained.

The governing of the engine is attained by slightly revolving the gas-pump piston valve, which has Ryder slots; this regulates the suction of the pump. As this valve is of large dimensions, the governor does not actuate it directly, but moves the piston valve of a small hydraulic relay which, in turn, actuates the main piston valve. The speed can be regulated and the air delivery varied by simply adjusting the governor, which is fitted with a hand-wheel for the purpose.

The engine is equipped throughout with a forced-feed system of lubrication, the oil being pumped to the different points, collected, automatically filtered, and circulated again.

The Marine Engine of the Future

Your editorial in a recent issue of POWER on the passing of the steam engine for marine propulsion before the advances of the steam turbine, suggests a bit of speculation as to the probable longevity of the latter in view of developments along other lines. In spite of its numerous advantages, the turbine has inherent faults which will probably prevent its ever becoming the foremost prime mover for ships. The acknowledged desirability of a power-transmission medium for speed transformation warrants this belief; the increase in complication, weight, first cost, or greater possibility of breakdown, makes questionable the advisability of adopting such auxiliaries. Lack of reversibility, the requirement for high speeds and the low efficiency at light loads stand against the turbine. The greatest objection, however, rests upon its dependence on the steam boiler. When an immense boiler plant, often occupying the greatest and most desirable part of the vessel, has to be inclosed within a structure strong enough to withstand the strains of rough seas, and the combined weight is pushed through the water at a high speed, the efficiency, referred to the carrying of useful load by the heat energy of the fuel, is necessarily very low on the modern ocean flyer.

Of all prime movers which have as yet been introduced, the internal-combustion engine seems nearest the ideal for marine service. Here the working fluid is air, which is just as pure at sea as on land. By using liquid fuel, the engine is complete in itself and the machinery space can be reduced to a minimum. This, in conjunction with its high efficiency, renders possible speeds and propelling radii which are out of question for steamships.

The combustion engine, it would seem, merely awaits development along rational lines. Of course, there is a possibility that it may not yield to a development along such lines, but it would certainly seem well worth a strenuous effort to apply at least some of the principles which are well known to be conducive to economy. As at present constructed, conditions prevail which are almost analogous to those found in the early steam engines where expansion and condensation were both effected within the same cylinder, with this important difference, however, that dry air is one of the best known nonconductors of heat and, therefore, not seriously affected by adverse surroundings. To compress a gas with any degree of efficiency requires provision for keeping the gas cool during the operation, whereas, in order to obtain the most work from an expanding gas it is essential to prevent as far as possible dissipation of the heat energy within the gas to other objects. It hardly seems rational to perform these two operations, which call for diametrically opposite conditions, within the same cylinder, as is done in the gas engine. Of course, when operating with a working fluid at such high temperatures as are reached in gas engines, it is essential that the working surfaces be protected from the influence of the excessive heat. It would seem practicable, however, to reduce heat losses through the cylinder walls by protecting such surfaces as are not subjected to mechanical wear. Such a cylinder designed for expansion only and operating in conjunction with compression cylinders, especially designed for their specific needs, would give a fair approximation to the ideal, especially if the exhaust gases are made to heat the compressed air on its way to the expansion cylinder. Such an arrangement would, moreover, render possible the embodiment of certain valuable features which are unavailable in the ordinary combustion engine, namely, the ability to start under load and to run in either direction, both of which are essential in large marine engines. The only reason why development is not being pushed in this field so full of possibilities would seem to be that about thirty years ago, and at a few intervals since, Brayton and other engineers made unsuccessful efforts to bring the constant-pressure combustion engine up to a practical plane. The cause of all these failures, so far as the records show, are traceable to failure on the part of the inventors to appreciate one fundamental principle which must be embodied in all successful combustion engines: the working fluid must not only enter the engine cylinder but also leave it at relatively low temperatures. The maximum temperature, owing to its degree of intensity, must be produced within the cylinder and then as far as possible destroyed therein by a long-range adiabatic expansion before being exhausted. Working with maximum pressures of about 60 pounds per square inch, such as these early experimenters adopted, the range of expansion was so limited that there was no possibility of commercial success. These efforts, however, had the unfortunate result of producing an almost universal skepticism of any possible future for the constant-pressure combustion engine.

The advantages of an engine free from all danger of pre-ignition regardless of the pressure of compression, having the highest theoretical efficiency, with the flexibility of a steam engine and capable of development into large powers with a minimum weight of material (made possible by the high working pressures allowable and the principle of making each element of the machine perform only that function for which it has been especially designed) should not be obscured by a few unsuccessful efforts along allied lines.

H. B. STILZ.

Philadelphia, Penn.

Temporary Excess of Steam in Producer

When the load is thrown on a suction producer suddenly, after it has been running light for some time, additional steam to the producer will make the engine "take the bit in her teeth." The extra steam should only be supplied temporarily. Raking hot coals into water in the ashpit or turning water into the hot ashes does the business. Why?

DOW R. WALKER.

Chicago, Ill.

Experiments with steam-raising by means of peat have been made by the Swedish railways on the Southern line, but they have turned out a failure. According to the report, the peat, especially if used alone, has not shown satisfactory results with the present types of locomotives. In the meantime, however, it is stated that valuable experience has been gained as to how locomotives suitable for peat ought to be constructed, and that the railway authorities are about to recommend the construction of some locomotives especially designed for the use of peat instead of coal.

Professor Remington recently cited a very interesting example of a physical phenomenon. A still in the chemistry laboratory had become empty and was red hot. Cold water was turned into it, and contrary to all suppositions the boiler blew in instead of out. Similar experiments have been tried by eastern railroad companies, and the same results have been reported.

FROM·READERS·WITH SOMETHING·TO·SAY

Practical Information from the Man on the Job. A Letter good enough to print is good enough to pay for

Roller Bearing Governors

The accompanying sketches illustrate the usual experience in the use of roller bearings in inertia governors. A roller bearing that oscillates will soon become unfit for the purpose of reducing friction on account of the practice of manufacturers of mounting steel rollers on soft pins with soft cast-iron bushings

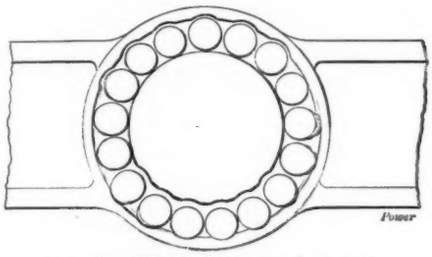


FIG. 1. WORN ROLLER BEARING

For the pin, hardened steel should be used and the arm should have a hardened steel bushing, which should be lubricated. Improperly made parts wear and the working of the governor is impaired to such an extent sometimes as to make the engine unsafe.

The pins are often too small. If they were twice the usual size it would be much better. More rolling surface on the pin would mean less friction on each roller. The condition of one governor is shown by the grooves in the pin, and in the arm, Fig. 1. When the parts become worn in this way the rollers will lock and cause the engine to race.

The governor pivot has long been a problem, but the pivots can be made in

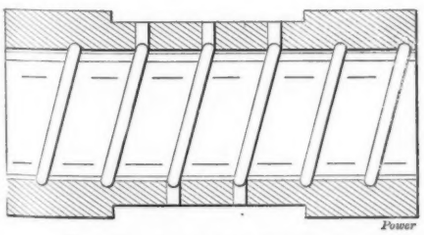


FIG. 2. IMPROVED BUSHING

a better manner and of better material and will be when engineers demand it.

After the rollers become seated the governor will hang and overspeed before the weights move. I have removed this type of bearing and put in antifriction metal bearings with much better results. This bearing has a deep oil groove, as shown in Fig. 2. As the groove is cut spirally, only a slight movement of the arm is required to lubricate the surface of the pin. Many power-plant engineers have lots of trouble with this one thing. The bushing shown in Fig. 2 has an oil cavity and perforations leading into the the spiral oil groove. The roller-bearing governor when new is like a governor that has no dashpot, while the bearing suggested acts as a dashpot and affords the same degree of friction at all times. I have had sufficient experience with the roller-bearing problem to be in position to justly criticize its workings from the manufacturing as well as practical standpoint.

C. R. MCGAHEY.

Richmond, Va.

Ice Making Troubles

On taking charge of a 50-ton ice plant the proprietor asked me to take a look at the ice and tell him what I thought of it. He had not had good ice since the new reboiler and cooling coils had been installed. I found the ice was full of air and had a large red streak running through the center. I started in by getting some lye and cleaning out the reboiler. After this, I removed the steam coils and scraped them, also cleaned the skimming tank and cooling coils. I found the charcoal in the filters as fine as sawdust and full of grease and a red substance. When I asked for a new charge of charcoal I was informed that new charcoal had been placed in the filters two seasons before and consequently did not need a new charge. I was supposed to take the old charge out and wash it, which I did not do but cut the filters out of service.

On starting up the plant again, I was sadly disappointed for the ice was as white as a bale of cotton and the red streak was as prominent as ever. On examining the system I could not discover any chance for air or raw water to enter. All the bolts that held the return bends in place were tight, and the automatic valve held a pressure on the coils.

Taking out a plug and putting a pressure of water on the coils I discovered cooling water leaking through and ascertained that the return bends were not set up hard enough to expand the rubber gaskets against the inner pipe; this allowed the cooling water to leak through and mix with the distilled water whenever the regulating valve opened. After making the return bends tight, the ice was as clear as a pane of glass and the red streak entirely disappeared.

It was customary for some of the office force to watch the side track and when a meat car was run in, go out and sweep up the salt and add same to the brine in the tank. In consequence, the brine was very dirty and the circulation sluggish. In looking for the cause of the poor circulation I found pieces of meat, sticks and waste wedged in the coils where the partition was cut away and where the brine crossed from one side of the tank to the other. After removing the "hash" the circulation was improved.

In another plant the reboiler was in a very exposed position and whenever the wind blew from an easterly direction the water would cease to boil; consequently there was a great deal of air-shot ice pulled. The trouble was removed by building a shed over and around the reboiler.

H. L. VINTON.

Buchanan, Mich.

Boiler Cleaners

There are many differences of opinion among engineers as to the proper way to clean boilers. Some will advocate a good boiler compound and some kerosene oil; some one thing and some another. I have had many years' experience with boilers and have tried every known way of cleaning them and I am going to give my brother engineers the benefit of my experience.

I find that the best way to clean a boiler and keep it clean, is to use a first-class mechanical boiler cleaner. I have no interest in any cleaner; there are several good ones made which can be installed at a reasonable cost.

When water enters a boiler and is brought up to 212 degrees Fahrenheit all the foreign matter rises to the top in the form of scum. As soon as it reaches the top it seeks the place of lowest temperature, which is the bottom of the boiler at the near end, but owing to the buoyant nature of the scum, it remains on top until it reaches the near head. Contact with the head causes the scum to precipitate to the bottom where it rolls toward the front and usually forms a scale directly over the fire. This rolling forward is caused by circulation. The scale adheres to the plate and remains until removed by some special agency. If allowed to remain it becomes thicker and firmer, soon begins to tell upon the

fuel bill, and will finally burn the boiler.

A mechanical boiler cleaner properly attached to the boiler will not only prevent scale forming, but will actually remove that which is already formed.

W. A. GARRIGUS.

Chattanooga, Tenn.

Hopes for the Fireman

The absence of reading matter pertaining to the fireman has prompted the writer to submit a few remarks to him. The young man who desires to become an engineer must put his foot on the first rung of the ladder before he attempts to reach the top. The fireman's part is never recognized as very important. Nevertheless, the duties which he performs cannot be dispensed with without breaking the circuit in the work. What use would the machines or the operators be unless steam was generated?

The trying circumstances under which he performs his duties should not be overlooked. At times he is bewildered to know who his boss really is and if he is easily "bluffed" he will find authority to extend even to the porter. The writer is not an enthusiastic advocate of the "college engineer" unless he has had practical training. We see men turned out from engineering schools whose minds seem to be quite thoroughly trained. On the other hand, we see men who have had no educational opportunities, but who, by their own unaided efforts have disciplined and educated their minds as thoroughly as any man who has ever been through college. It is not of importance how much school or college he gets through, but how much school or college gets through him.

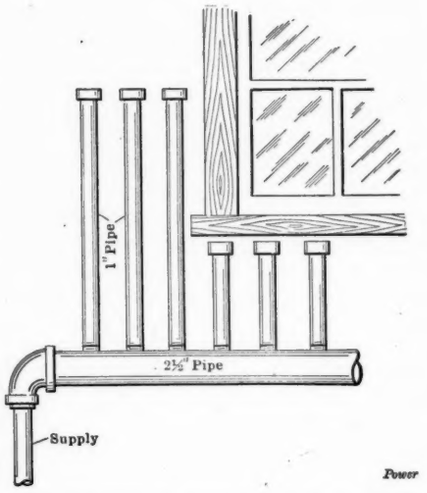
While education is the great foundation of success, practical training must also be acquired. This applies particularly to operating engineering. By helping here and there, the fireman may get a general idea of the work. This experience he finds beneficial when later he takes up the work in detail. Always be on the lookout for the opportunity to learn. Once a thing is learned it costs nothing to carry the knowledge about and it is always ready to use. Make friends of those who know more than you, rather than those who know less. Don't be satisfied simply to follow the methods shown you, but study during your spare time. Pay careful attention to the instructions of those who teach you. Learn all you can from them. Remember that you can become more valuable by adding to your knowledge of your work, and that a few hours devoted to study each week will soon fit you for a higher position and greater responsibility.

JAMES G. SHERIDAN.

New York, N. Y.

No Heat Without Circulation

The figure shows a large radiator we made that may be of interest to POWER readers. We had 75 feet of 2½-inch extra-heavy pipe drilled and tapped on 3-inch centers for 1-inch pipe. There are 282 pieces of 1-inch pipe and all except those under windows are 6 feet long. When we turned on steam, we were greatly surprised that the 1-inch



THE HEATER WHICH DOES NOT HEAT

pipes did not heat up for more than 1½ feet from their lower ends.

Will some reader kindly advise us what we can do to make the radiator work better.

W. CHINSANO.

Brooklyn, N. Y.

Blowoff Piping

As erected by the contractor, our boilers were fitted with blowoffs dropping 1 foot from the shell, then going through the combustion chamber to the outside of the wall of the first boiler. When No. 1 boiler was run and the pipes from Nos. 2 and 3 were empty, they became so heated that they warped and had to be removed. I located the new pipes at the bottom of the combustion chamber and covered them over. I used extra-heavy pipe and had no further trouble for years.

In connecting up feed pipes, I put in bottom and top feeds so valved that I can use either of them separately. The bottom feed is through the blowoff and connected close to the blowoff valve, so that when the pipe gets clogged with loose scale or mud and the boiler cannot be blown down, I shut off the feeds to the other boilers and apply the boiler-feed pump. If the obstruction does not dislodge readily, I open and shut the blowoff valve several times, which directs the pressure first one way and then the other and always results in clearing the pipe. I have found the top feed to be more satisfactory and economical than feeding through the blowoff.

Kerosene oil as a scale preventer or remover has no effect on the water we have here. As for its scale-dissolving qualities, will say that I have had some scale in a bottle of kerosene for 18 years without observing any change in the scale whatever.

A. W. WILSON.

Sterling, Ill.

Natural, Induced and Forced Draft

Among many engineers there is a prevailing prejudice against artificial draft, the supposition being that the greatest economy is to be secured by natural draft. This is true, in some cases, but only where the load is steady and always well under the rated boiler capacity. In such cases a steady steam pressure can be maintained without forcing the fires, and the damper will be entirely or nearly closed most of the time, thus preventing the excessive inrush of cold air that occurs with hand firing, firing and the damper open. Light firing tends to a small amount of wear and tear to furnace linings and grates, and as a rule a higher equivalent evaporation is to be attained under a light load than when the load is over the rated capacity of the boiler.

It is a common argument that natural draft is the most economical, because it costs nothing to produce it, and that artificial draft should not be adopted, except in cases where it is necessary to force the boilers, owing to shortage of capacity. But if natural draft does cost nothing to operate it necessitates a considerable first cost outlay for a much taller stack than is needed with artificial draft. Natural draft is only created by, and in proportion, to the difference in density of the outer air at the level of the furnace and the heated and expanded gases emerging from the top of the stack.

The analysis of the flue gases under natural draft conditions usually proves the presence of a large excess of free air, and the quantity of heat absorbed in raising this excess of air to temperature of the true gases of combustion passing to the stack robs the water in the boiler of just that amount of heat.

A pound of dry coal containing, say, 85 per cent. of carbon and 2 per cent. of hydrogen requires not less than 2.28 pounds of oxygen for complete combustion. This amount of oxygen is contained in about 120 cubic feet of air. If such economy should be attained in practice an analysis of the gases of combustion would show no excess of air, and no oxygen would be found uncombined. Instead of the 21 per cent. (the

constant volume) of oxygen in the air before combustion, 19.5 per cent. of carbonic-acid gas (CO_2) and 1.5 per cent. of water vapor would have developed, and the remaining 79 per cent. would be the nitrogen of the air, which plays no part in the chemistry of combustion.

As the water vapor does not appear in the automatic CO_2 recorders, or the Orsat apparatus, the percentage of CO_2 is taken as the measure of economy in the adjustment of the air supply in practice. It is not possible to produce 21 per cent. of CO_2 in the flue gases, owing to the presence of small quantities of hydrogen in the coal, and because the CO_2 when first formed and the carbon is too much restricted in its supply of oxygen, has a tendency to undergo partial dissociation, in passing through the fire, and some carbonic-oxide gas (CO), is formed. It is possible, and practicable, to work with the average percentage of CO_2 as high as 15 per cent. without the formation of CO, and without too large an amount of excess air.

Supposing, for example, that a coal requiring 120 cubic feet of air per pound was being burned in a furnace, and that a volumetric analysis of the flue gases showed the composition to be 16 per cent. of CO_2, 4.2 per cent free oxygen, and 79.8 per cent. nitrogen. From these we find that out of the 21 per cent. available oxygen in the atmosphere 4.2 per cent. has not combined with carbon, hydrogen or any other element, but is still *free*, and that 16.8 per cent. has combined, partly with carbon as CO_2, and partly in forms that do not appear in the testing apparatus. This means that a volume of free, or excess air, equal to 25 per cent. of the volume of the useful air, is also passing through the furnace, and requires heating up to the temperature of the rest of the escaping gases.

It is rare, under natural draft conditions, to find that even 10.5 per cent. of the oxygen has entered into combination, which means that there is, at best, as much free, as used air present, which means that the furnace is taking in 100 per cent. of air in excess. A more common thing by far is to find 200 per cent. excess.

In addition to the 120 cubic feet of air necessary to burn one pound of this coal the analysis of the flue gases shows a volume equal to one-fourth of that, or 30 cubic feet, in excess. Thirty cubic feet of air weigh approximately 2¼ pounds, and the quantity of heat required to raise this amount of air from atmospheric temperature, say, 60 degrees Fahrenheit, to the temperature of the gases leaving the heating surface of the boiler, say, 400 degrees Fahrenheit, is about 153 B.t.u. Assuming the coal to have a heat value of 13,500 B.t.u. per pound, this would represent a loss of 1.13 per cent. of the fuel in heating excess air instead of the water in the boiler. Where the excess air is from 100 to 200 per cent. the losses of the same fuel from the same cause would amount to from 5½ to 11½ per cent. of the fuel, which is an excessive and needless waste.

Induced draft, in some installations, is a necessity, but its range of most useful application is limited to cases where the stack is too small in area or hight. There are numerous such cases where the full amount of work cannot be obtained from the boilers, on account of insufficient draft to burn the required amount of coal, and where forced draft, if applied for this purpose alone, would cause such a back pressure over the fire as to seriously overheat the fronts and be a source of danger to the fireman on opening the doors.

The ideal conditions under which to run a boiler plant, are to maintain a balance of draft, while working with the minimum practicable quantity of excess air. To secure this, it is necessary to work with a closed ashpit, and under a forced draft of sufficient pressure to balance the "pull" of the chimney; whether the pull of the chimney is caused by naturally induced draft, or artificially induced draft does not matter.

By this system the best results in fuel economy and boiler efficiency are to be attained, for it means the prevention of inrushes of cold air, large excesses of air, and insures a more rationally proportioned distribution of the duty over the heating surface of the boiler. The balance of the draft should be so adjusted that when the door is opened, and a handkerchief suspended before the opening there should be no tendency to pull it in, and, at the same time, no outrush of flame, due to pressure over the fire. These conditions cannot always be maintained to perfection, however. A prevailing supposition is that forced draft is only another name for forcing the boilers. A boiler can be forced harder with forced draft than natural draft, if that is the object, but it is not the way to get the best results in fuel economy. Tests of boilers before and after the installation of forced draft have shown that the saving amounted to from 10 to 20 per cent. when using the same fuel and not forcing the boilers.

There are cases on record of leaky tubes, bagged plates, and even the overcarriage of water to such an extent as to cause the knocking out of cylinder heads, and all ascribed to the evils of forced draft, but very few things in this world are foolproof, and most things have their abusers.

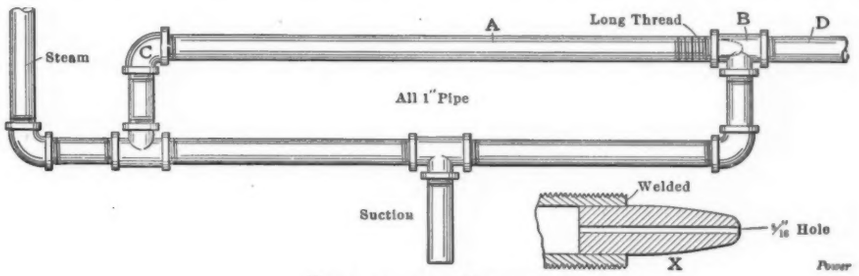
Forced draft, properly understood, means controlling the supply of air to economically burn the fuel, and accomplishing this with the least possible percentage of the boiler's gross production diverted to the process. Well designed fan installations absorb from 2 to 2½ per cent. of the total steam to do their work, but this is usually a trifle compared with the increased efficiency, and the saving effected.

H. S. FLYNT.

Newark, N. J.

Homemade Ejector

The method of making an ejector is well known to most engineers, consisting of a tee in which a small pipe is fitted in a reducing coupling or bushing, which is connected to steam line, the bottom of the tee being connected to the suction pipe and the other end of the tee used as an outlet. Such designs of ejectors have very little force, and for that reason make it somewhat more or less nasty wherever it is working.



EJECTOR AND NOZZLE

A design recently noted in an engineering plant is shown in the illustration. It is made from 1-inch pipe throughout, and needs but very little explanation with the exception that the nozzle shown at *X* is welded to the pipe *A* and extends to the position shown in the tee *B*. The pipe *A* has a long thread, screwing into the tee *B*, and when connected to *C* is unscrewed until the joint at *C* is made tight. The nozzle has a 5/16-inch hole drilled in it before the welding process takes place.

This ejector not only lifts the water, but forces it from the outlet *D* with considerable force. The engineer who designed this device states that he has used his for some time and has never known it to fail to pick up and operate at the first trial. The illustration speaks for itself as to the manner of construction.

W. O. REGAN.

New York City.

SUBJECTS UNDER DISCUSSION

Comment, criticism and debate upon various articles, letters and editorials which have appeared in previous issues

Receiver Pressure

Several years ago I got a job as night engineer from a man whom we will call Dick. One night he visited me and among other things asked me how I knew how much receiver pressure to carry. I suppose he saw from my way of answering him that I did not know anything about the subject so he said he would show me how he knew. We had two compound engines, 18 and 32 by 42, running 90 revolutions per minute. The steam pressure was 132 pounds and the vacuum about 20 inches. The load consisted of three 150-light, brush, arc machines and one alternator on each engine, both being about equally loaded. Dick simply noted the position of the governor on each engine and lowered or raised the receiver pressure until the governor spindle was in the highest position it would assume. It was very evident that the earlier the cutoff the less steam the engine would use per revolution. The receiver pressure for the highest position of the governor was about 20 pounds.

A few years later, I took part in a test on a large, vertical, cross-compound, condensing engine, 46 and 94 by 60, running 75 revolutions per minute. The steam pressure was 170 pounds and the vacuum 26 inches. About 10 degrees superheat was maintained. The load was 3000 kilowatts.

We were all in hopes we would run the turbine a close race, and after about a two-hour run we began to figure up results. You can imagine our surprise when 20 pounds of water per kilowatt-hour was announced. Our receiver pressure was about 12 pounds. I raised it to 16 pounds and in the next two hours the water consumption dropped to a little over 18 pounds per kilowatt-hour. The receiver pressure was then run up to 20 pounds and for the next two-hour period the result was a little over 17 pounds per kilowatt-hour. Of course, our average for the day's run was not what we expected, but it was better than it would have been had we not raised the receiver pressure.

The next day we started with 20 pounds receiver pressure, other conditions remaining the same, and the result of a seven-hour run was 17.27 pounds of water per kilowatt-hour.

Now I thought I knew why raising the receiver pressure cut down the steam consumption per kilowatt-hour, but since reading so much about it in the columns of POWER, have concluded it was best to wait and hear the outcome of the discussion. So I submit the question to the readers as to what would be the most economical receiver pressure to carry under the conditions set forth above.

I did not try any higher receiver pressure than 20 pounds for I concluded the water rate obtained with this pressure was good, and besides, if any of you have tried 20 pounds on top of a 94-inch piston with 26-inch vacuum under it, you probably know why I did not raise it any higher.

EDWARD LANE.

Kansas City, Mo.

Safety of Manning Boilers

C. D. Thurber on page 1102 expresses doubt regarding the safety of the Manning boiler, under the forced condition which is customary in the New England textile mills at starting time. If the lifting of water due to hard firing could be a real cause of such an accident as occurred at the Amoskeag mills recently, Mr. Thurber's alarm would be more than justified; for if there is any class of accident more alarming than another, it is a boiler accident due to causes beyond the control of the engineer-in-charge. The theory of the lifting of the water causing bags or overheating of the plates or tube ends in tubular boilers deserves to be classed with the theory of the formation of a blue gas or electricity in boilers, as a means of explaining explosions.

There is a bare possibility of forcing the water out of a tube of a water-tube boiler for a sufficient interval of time to cause overheating of the metal, but such cases are rare, and require unusual conditions to produce them, and the same conditions are, in the opinion of the writer, absolutely impossible in the tubular type of boiler. Anyone who is interested, might try to heat up a piece of tube end or plate in a forge fire to a point where it would begin to lose its physical characteristics, and note the time that is required to accomplish the result; and then, remembering that the transfer of the heat from the plates or tubes to the water is much more rapid than from the fire to the metal, and also that the instant that the water is separated from the plate by steam, the generation of steam practically ceases, he will have a fair idea of the impractical conditions that would be required to exist to produce such an accident as that at the Amoskeag mills by the overheating due to lifting of the water in the boiler.

The writer's opinion as to how the accident occurred is as follows: The boiler had only four openings on a line with the crown sheet for the removal of scale from this portion of the boiler, these openings being located on the cross aisles between the tubes. With such design (as anyone knows who has been up against the proposition), if the water has a tendency to form scale on the crown sheet, it is almost a hopeless task to either inspect or clean the lower ends of the tubes or the crown sheet between the tubes. It is the writer's opinion that scale or deposit had accumulated on the crown sheet to such an extent that together with the forced firing, the tube ends became overheated and as there was no beading on the tubes to act as a stop to prevent their coming through the sheet, they pulled out. It was necessary for only comparatively a few to start to throw an excessive load on the neighboring tube ends sufficient to pull them off. This starting of the tubes to pull out was not necessarily at a time when the tube ends at this point were hot, for it is not at all infrequent for a tube end to become overheated and the metal to upset in the act of overheating, so that when the water finally reaches it and cools it off, the diameter of the tube may be 1/32 of an inch less than that of the hole into which it is expanded. This condition with the beaded tube can, however, hardly become dangerous, for before a point where a number sufficient to render the holding power of the beading alone precarious is reached, severe leaking at the tube ends attracts attention. Mr. Thurber can make his boilers practically immune from the sky-rocket movement of which he is apprehensive by following the lead of the foremost manufacturer of this type of boiler in New England, who has advocated and built them for years with beaded tube ends and a series of handholes on a line with the crown sheet, permitting the inspection and thorough cleaning of this sheet and the tube ends, between every aisle of tubes. So constructed, and with reasonable care, it is one of the safest types of boilers built and this bars none of the water-tube or sectional variety which have the word "safety" emblazoned on their fronts.

C. A. GILES.

Boston, Mass.

Don'ts for Engineers

Referring to "Don'ts for Engineers," by H. E. Wood, I would like to see the fireman who could prevent smoke with a standard horizontal tubular-boiler setting and Indiana coal. We will put him on for a few days at a very fancy price just to show us. The volatile part of Indiana coal begins to distil off as it passes through the fire door. This coal can be burned without smoke, but not in the chilling atmosphere of a big shell full of water at a temperature of about 400 degrees.

Also, he says, "Don't let too much smoke escape from your stack." Brother, we just *have* to let it escape, there's more to follow. Don't think we haven't tried coking fires, light fires, alternate-door fires and other kinds; we have, and are just aching for some fellow to show us how to prevent the smoke.

Having been in the water-boiling business since the days when Indiana was full of wild turkeys, deer and other things of like nature, I recognize some things that have come down from our forefathers. One is, that all that is required to prevent smoke is a skilful fireman; another, that low water is the principal cause of boiler explosions. To the latter, this adage applies, "The bridge that is not strong enough to carry the load breaks down."

We sometimes meet men who deplore the fact that boiler iron is not what it used to be. We remember some of that iron on which we could use a chisel and split a section two feet square without running out on either side. How long would one of those old plants stand up under the modern pace?

"Smoke is an extra expense." I agree it is, but believe it is an expense more on account of the coating it forms on the heat-transmitting surfaces than on account of the unconsumed carbon escaping from the stack.

Mr. Wood says, "Don't screw a valve clear open, and let the stem stand tight." He should qualify this. On an engine line or where there is vibration, open the valve until the valve jams against the bonnet; otherwise the disk will move with every vibration and soon wear the valve out.

"Don't use a wire to clean out a gage glass." Correct, but we always wondered why a glass that had been touched on the inside by a piece of metal would break even when not put in use.

"Don't think it necessary for a crank-pin box to fit tight sideways." Only last week one of the youngsters in charge of the engine driving a dynamo had his crank-pin box melted out solely because of a rather close fit. It costs money to make engineers, but on the whole, I believe it pays.

"Don't forget that a long angle joint is better than a short one in a steam ring." Say, there is a whole sermon in that.

"Don't rebabbitt a connecting rod and put it to work without lining it with both pins." We did that last week, only scraped it to a near fit; did not have time to line it. We removed the metal that had not melted out, set a piece of 6-inch pipe inside the boxes, poured the metal, bored them out and scraped them; the engine runs nicely. We heated the pipe and boxing with a plumber's torch before pouring. An engineer should have, above all else, excepting a hammer, chisel and monkey-wrench, a hacksaw, gasolene torch and a soldering outfit. How many of us are handy with a soldering iron? Don't all stand at once.

"Don't be stingy with oil." We are not. The modern idea is to flood the bearings with oil and use it over and over.

"Don't allow curious boys alone in the engine room." That is certainly good advice.

Brother Wood is certainly to be commended for the excellence of his "Don'ts." I only comment on them in an effort to start the youngsters to thinking, because I always consider the man who won't think as intended by nature to be a manual laborer. Anyway, that's where he brings up.

J. O. BENDER.

Anderson, Ind.

Safety Necessities and Safety Devices

Rightly speaking, the editorial on this subject which appeared in the December 14 number, deserves no discussion. It is not logical.

The writer thereof goes to considerable length to tell us that neither a man nor a machine is infallible. After this, we would expect to hear that every mechanical safety device should be employed in order to minimize the liability of disaster resulting from man's fallibility. Not so, however; under certain circumstances he prefers to pin his faith on the man, while under other conditions he will put his trust in the machine.

A distinction is made between what the writer pleases to call safety "necessities" and safety "devices." In his category of "necessities" are the safety valve, the water glass and the steam gage. The safety "devices," that is to say, the things not absolutely necessary are the low-water alarm, the automatic feed regulator, etc. The gage and the water glass would be of no use whatever, unless there was a man around to read them; but an automatic feed regulator would probably keep the boiler properly supplied even if the man went blind or became locoed or dropped dead. And a balky feed regulator could not be more mischievous than a deranged water glass or steam gage. The automatic feed regulator belongs with the safety "necessities."

The low-water alarm is a mighty cheap insurance against a somnolent attendant, a deceitful water glass or a disabled feed-water regulator. I am for calling it also a safety "necessity."

Too much safety is not obtainable. Any device designed to increase the degree of safety is a necessity, for while neither man nor machine is infallible, the liability of both going out of service at the same time is very remote; hence, the degree of safety is highest when one supplements the other.

AMOS CHAIS.

Philadelphia, Penn.

Some Limitations of the Steam Turbine

Warren H. Miller's article under the above title interested me greatly. The limitations given by Mr. Miller vary greatly from what I should consider them to be. Compared with reciprocating engines, turbines are at a great disadvantage when running under high pressures. As to fluctuations of load, I have never seen a reciprocating engine that could begin to take care of sudden and heavy variations, from almost no load to 50 and sometimes 100 per cent. overload, as easily as the turbine, and my experience with reciprocating engines covers a period of over seven years and includes units of both low- and high-speed types ranging from 50 to 2500 horsepower.

As to variations of steam pressure, any turbine that I have had anything to do with would carry its rated load under as great a variation of pressure as any reciprocating engine I ever saw. I have never noticed that it was any harder to recover the steam pressure with a turbine installation after it had dropped than it was with a reciprocating engine taking steam full stroke.

In regard to watershots I can best explain their effects by describing an incident which occurred in a plant, consisting of a number of 2000-kilowatt turbines, in which I had charge of the watch at the time. The load was light, only two units were running, No. 1 and No. 4. When passing the switchboard I noticed No. 4 was carrying practically all the load. Just then the oiler called me to No. 1 turbine, and pointed to a stream of water as large as a lead pencil running from the throttle-valve stem. Hurrying to the boiler room I found the boiler opposite No. 1 to be full of water.

After having the boiler blown down to the proper level I returned to the switchboard and found No. 1 again carrying its share of the load. I wonder what would have been the result if No. 1 had been a 3000-horsepower reciprocating engine instead of a turbine.

As for the generator fields getting out of balance, I have never operated turbines with a speed of 3000 revolutions per minute, but have had charge of a plant consisting of three 500-kilowatt Curtis turbines running at 1800 revolutions per minute for over four and one-half years and in that time have had occasion to balance but one field and found no difficulty in doing that myself.

Mr. Miller says, "Never tie up the power in anything that the workshop cannot repair with a few essential spare parts." In this respect the turbine has an advantage over the reciprocating engine. In the plant I have charge of at the present time, I carry an extra set top, middle, steady and step bearings besides a few carbon packing rings. The extra step bearings have never been used; the steady bearings have been changed once in four years. The top and middle bearings are changed on an average of once every eighteen months. I find the turbine valves need overhauling occasionally, but the parts that need renewing are simple and I usually make them myself. The governors have had new links installed once in seven years' time.

A. W. Dow.

Newport, R. I.

What "Tom" Sawyer Wants

In the November 16 and December 14 issues of POWER, "Tom" Sawyer wants to have someone demonstrate why an engine will run with less steam with compression than without it. Now, it does not take any great intelligence to know that if we advance the eccentric on a common slide-valve engine we get more compression. We also get an earlier cut-off. Nearly all writers on compression confine their argument to the fact that the clearance space if filled by compression does not have to be filled with steam from the boiler. They might add that the initial condensation is much less with the steam entering the cylinder at boiler pressure and finding the piston at the temperature of steam at 25 pounds, than it is if the steam enters a cylinder the temperature of which is that of steam at atmospheric pressure.

If it took power to produce compression, there would be no saving in steam, but it does not take any. In fact, we are saving power when we stop the piston, crosshead and connecting rod at the end of the stroke by compression instead of taking power from the flywheel to stop them. If the combined weight of the piston, crosshead and connecting rod is, say, 500 pounds, and we have a piston speed of 600 feet per minute and this 500 pounds has to be stopped 200 times a minute it takes power to overcome the inertia, does it not, Mr. Sawyer? Now if we do not overcome this inertia by compression, will Mr. Sawyer tell me what does overcome it? Where does this power, required to bring them to a state of rest, come from? If Mr. Sawyer would stop to think, he would see that it is taken from the momentum of the flywheel and tends to retard its velocity, and the cutoff must take place just a little later in order to make up for it.

An engine should have just enough compression to bring the reciprocating parts to a state of rest at the end of the stroke. Any more is not economy. Mr. Sawyer demonstrated this when he reduced the receiver pressure of his compound engines. If he had adjusted the exhaust valves of the high-pressure cylinder for the higher receiver pressure he would have gotten the same or better results. An engineer should use judgment in setting the high-pressure exhaust valves to the receiver pressure just the same as he would the exhaust valves of the low-pressure to run condensing or noncondensing; the higher the terminal pressure, the later the exhaust valves should close.

C. E. Bascom.

Marlboro, Vt.

Cast-iron Bearings

Although a farmer by vocation, I take interest in machinery and the transmission of power; hence, I am a subscriber to POWER.

A recent editorial on the advisability of using cast-iron crank and crosshead pins prompts me to tell of my experience with farm-machinery parts constructed of cast iron.

The life of any piece of apparatus may be said to depend upon its bearings; no matter how perfectly proportioned, or how carefully made, any machine is doomed if its bearings cannot be kept in good condition.

I believe that cast iron is more suitable in many cases than brass or babbitt metal for a bearing surface. A box made of cast iron will not wear out while boxes lined with brass or babbitt metal will. This has been the experience I have had with farm machinery during 40 years, in which time I have owned three large mowing machines. On each machine the box of the pitman shaft was cast iron. This box receives the most severe usage of all, and yet it gave as little trouble as any; it was always tight, and in good working condition, and required very little attention. Any brass or babbitt-metal boxes I have had anything to do with always required constant watching and no matter how thoroughly oiled, were ready to be consigned to the scrap heap long before the machine itself had outlived its usefulness.

R. R. Lambert.

Rush City, Minn.

What Made the Difference?

Referring to E. E. Russell's article on "What Made the Difference," in the December 7 issue, I think the principal difference is in the types of engines involved. Surely the Corliss engine was invented to give the user better service and economy in certain classes of work. Other types of prime movers have their fields of service where the same result is obtained. In this instance it would appear that the Corliss engine is in the proper place.

That the addition of load on the engine made no difference in the horsepower developed, may be due to different working conditions in the factory at the time the diagrams were taken.

If Mr. Russell had included the indicator diagram of each engine from which he figured the horsepower, and had given the necessary information, they would have been very interesting and a more thorough understanding might have been gained.

T. J. Hammersley.

Milwaukee, Wis.

Adjusting Indicator Cord

In the issue of November 30 there appeared an article by Julian T. Smallwood, on "Adjusting the Indicator Cord." The limitations of the method described by Mr. Smallwood as "the proper, easy way" may be illustrated by this example:

It is desired to indicate a cross-compound engine, the cylinders of which are 44 and 84 inches in diameter, with a 60-inch stroke. The flywheel alone weighs 125 tons, while a heavy rolling mill is direct connected to the engine. It is very evident that the cut-and-try method is much easier in this instance than Mr. Smallwood's, which involves setting the ponderous engine first on one center, then on the other, and finally in a half-way position.

Mr. Smallwood's method would not be practicable in locomotive work. In fact, I do not believe it is possible to obtain a universal method of adjusting the cord. Local conditions vary so much that it must be left to the intelligence and ingenuity of the man in charge to devise "the proper, easy way" in each instance.

C. W. Long.

Reading, Penn.

An accident happened in the power house of the Chattanooga Electric Light and Railway Company on December 17 which put the entire system out of commission for two hours. During a heavy snowstorm, a transom back of the high-tension switchboard had been left open, and the snow falling on the busbars caused a short-circuit which burned out a section of the board.

Effect of Superheated Steam on Cast Iron

A Continuation of the Discussion on the Three Papers Presented at Boston and Some Quotation to Show What Our English Cousins Think of Cast-iron Steam Fittings

A. A. Carey, consulting engineer of New York, said that the discussion of the past few years concerning the destructive effects of superheated steam on valve fittings and even engine cylinders has caused many would-be users of superheated steam to draw back in fear with the limited knowledge which they have acquired, rejecting its use in many cases where great benefit would follow its adoption, and in other cases accepting its use with fear and trembling when it became an indispensable necessity. There has been antagonism upon the part of some steamfitters who know that superheated-steam installations call for superior class of fitting, pipes and workmanship, and they know that calked joints and other cobbled up imperfections, so commonly resorted to in the installation of ordinary steam lines, would only lead up to future troubles when superheated steam is used. Continued flexing on one side of the flanges of fittings, due to the cooling and high degree of heating in the pipe system as steam is turned off or on, will cause ruptures not unlike those shown in the illustration accompanying these papers, and be apt to change the internal structure of the metal itself. As higher velocities may be used with superheated than with saturated steam, so much smaller piping can be installed, not only decreasing the cost, but also increasing the flexibility of the pipe line.

There is little reason to believe that the steam itself has any material chemical effect upon the metal, and an explanation must be looked for along the line of physical effect.

Using the analogy of the points of arrest in the cooling curve of H_2O, Fig. 1, as it passes from steam through water to ice, Mr. Carey explained the analogous points of arrest in the cooling curve of iron, Fig. 2, in passing from the liquid to the solid state through "gamma" and "beta" to "alpha" iron, and explained that under certain conditions the "gamma" iron, which was very hard, might be brought into the "alpha" condition for a portion of the curve without passing through the "beta" state. This produces an iron with unstable physical qualities, and as stated by J. W. Mellor, "It is supposed that the presence of many foreign substances, like carbon, nickel and manganese, augment the passive resistance so as to render the hard 'gamma' iron more stable and permanent at low temperature." On the other hand, the presence of chromium, tungsten, aluminum, silicon, phosphorus, arsenic and sulphur faciliates the passage of the hard "beta" iron into the soft "alpha" iron.

There are comparatively few tests available in this investigation of cast iron under temperatures below 1500 degrees, but certain tests were made at the Watertown arsenal (see report of 1888), where samples of cast gun iron were tested at various temperatures from normal to 1500 degrees Fahrenheit. The average of these tests showed the normal tensile strength of the iron to be 30,000 pounds. This strength was maintained until a temperature of 900 degrees Fahrenheit was reached, and from that point it dropped gradually until at 1100 degrees it was only 20,000 pounds, while at 1500 degrees the tensile strength had dropped to 10,000 pounds.

There is no reason to doubt but that a change in molecular structure occurred in this iron at a temperature of about 900 degrees Fahrenheit, and there is good reason to argue that with other grades of cast iron such a change would occur at a still lower temperature, which would doubtless account for many of the troubles reported as occurring in the cast-iron parts of pipe lines using superheated steam.

Tests for tensile strength have shown that the greatest tensile strength of mild steel is attained at about 500 degrees Fahrenheit, and that with a further increase of temperature its strength declines rapidly. The elastic limit of this steel also diminishes with increased temperature. The strength of copper and many of its alloys is seriously affected by heat, the loss not exceeding 16 per cent. at a temperature of 500 degrees, but being seriously affected as the temperature is increased above that point. The effect of the increased expansion, due to the higher temperature, was forcibly illustrated to him by the examination of a valve with a cast-iron body and a brass or bronze seat, used in a superheated-steam line. The seat had originally been forced into its recess under very great pressure and fitted it very securely. After a few months' use he was able to twist it around easily in the piece with his fingers. As the expansion of the seat was much greater than that of the valve body, the metal had actually been compressed into a smaller volume, so that when it cooled the condensed-metal seat became loose.

He referred to the valuable work which is being done through microscopic examination of metal, showing that iron and steel identical in chemical composition may possess widely different mechanical properties, which are quickly recognized by this method of analysis.

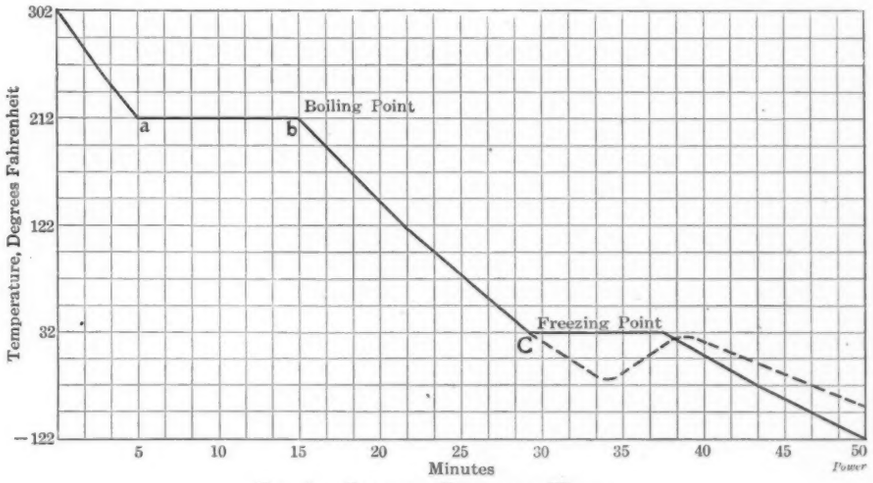


FIG. 1. COOLING CURVE OF WATER

In many superheated-steam lines one or two, or a very small proportion of the total number of fittings, have at times been found in bad condition, and the first small percentage of trouble had frequently led to the unjust condemnation of the whole system for superheated steam. As for engine cylinders it must be remembered that there is much more difficulty in lubricating with superheated than with saturated steam, nothing but the best quality of special lubricating oil must be used, but when this difficulty has been foreseen and provided for, the danger of using superheated steam with reciprocating engines is reduced to practically the same status as that attending the use of saturated steam.

Arthur S. Mann, author of one of the

papers under discussion said: "Many of us believe that cast iron loses strength after it has been heated, but that is also true, as Professor Miller has said, of rolled steel. Our superheaters are part of the boilers, usually tubes in the second pass. We have to cut out tubes every once in a while, and I have taken out tubes about ⅛-inch gage, after they had been used several years, and could drive a hammer through them in a good many spots. The metal had lost half of its strength, so that the fact that cast iron has been found in certain cases, perhaps in many cases, to lose strength does not necessarily unfit it for use. This deterioration is probably true of any metal. After a great many heatings and coolings they all lose strength, and this fact must be taken into account in designing. If we start with a metal having a tensile strength of 30,000 pounds and it loses 10,000 pounds, we have still got some left. If we start with 50,000 pounds and lose 10,000 pounds, we still have enough left.

Charles H. Bigelow said that he had seen cases in which there was a great deal of change of temperature with superheat, such as a drop to saturated-steam temperature from a superheat of 250 degrees in a very few minutes. It got so bad that they had to start the blowoff in the superheater every 20 minutes to keep the water from carrying over into the turbine.

William E. Snyder, chief engineer of the American Steel and Wire Company, of Pittsburg, said that in three instances which he recalled at the moment, in which there were Y's in the steam pipe to the engine, the throttle valve was cracked or broken where it bolts to the cylinder flange, and in one instance the throttle valve happened to be stronger than the top of steam chest so that the strain which was thrown onto the boiler here was transmitted to the cast-iron surface of the steam chest and burst off the whole top, causing a serious accident. In another instance with a 24-inch steam line having an 18-inch Y connection under 160 pounds pressure, the Y split right where it branches off. The leak was noticed in time to shut off the steam and reduce the pressure before the casting gave way. In fact, it did not give way entirely, showing how reliable cast iron is under certain conditions.

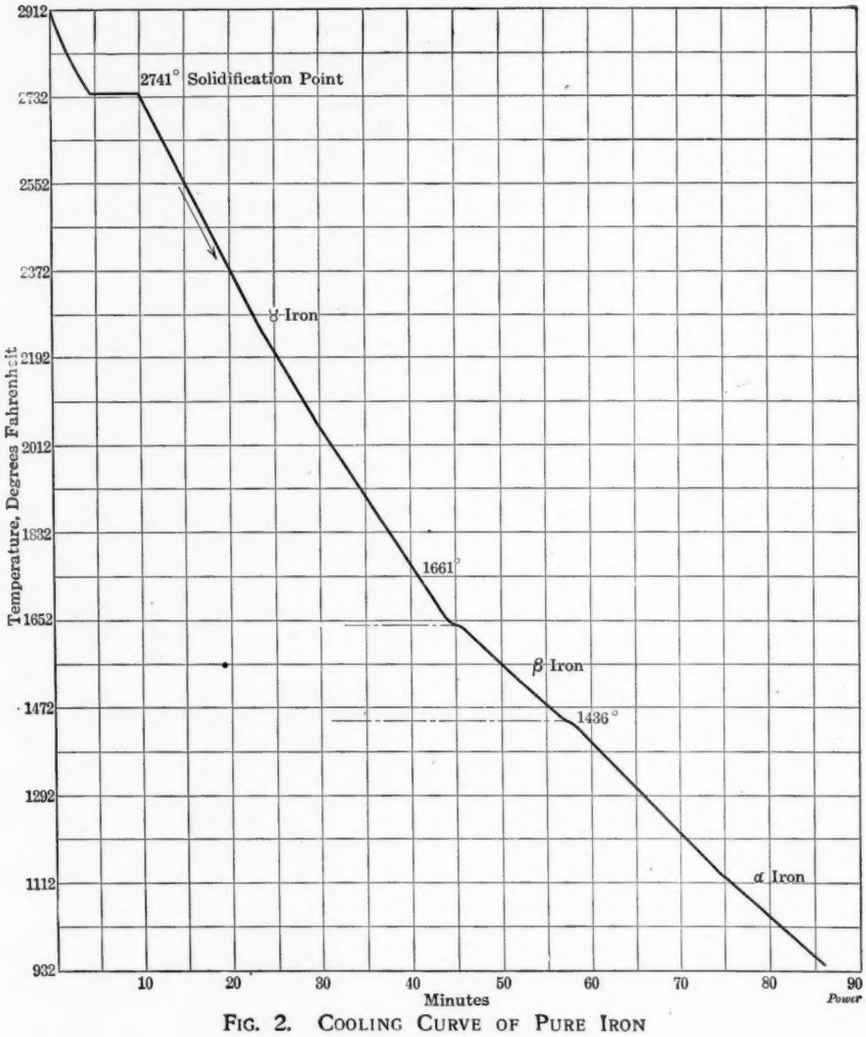


FIG. 2. COOLING CURVE OF PURE IRON

With regard to the tendency of cast iron to form cracks on one side as a consequence of being unequally heated, Mr. Snyder referred to a statement in a book by the chief engineer of the French navy relative to the effect of heat applied to boiler tubes in causing them to bend outwardly away from the fire. His theory, which seems reasonable, is that when the heat is applied to the bottom of the tubes it gives that part of the tube a higher temperature than the upper part of the tube and gives the lower part of the tube next to the fire a tendency to expand, while the upper part resists, sometimes to the extent of making it take a set, and when the tube cools down this lower part will contract, and this contraction resisted by the upper part will cause the tube to go upward and a crack to develop below. They had had some experience with cast-iron drums in Babcock & Wilcox boilers, and possibly the same reasoning applied there. (The reference was evidently to the mud drum in the back.) The gases passed from the furnace over through the first pass, down through the second pass and then up. There are times when the front baffle, or bridgewall, will get into such a condition that it will leak hot gas and quite a lot of the gas will pass through and strike the cast-iron drum in the rear. When this has occurred, it has produced a crack in the side of the drum next to the fire, which if not caught in time will go around the drum and cause it to burst. This has occurred several times. Touching upon trouble from variation in temperature, Mr. Snyder recounted an experience with a Cahall boiler over a heating furnace. The temperature of the gas would vary from 700 to 100 degrees, and the temperature of the thermometer in a Carpenter calorimeter attached close to the boiler would vary from about 375 to about 550 or 600 degrees, and that variation would occur in a very few minutes, depending on the way the heater supplied the gas to the furnace, and the quantity of waste gas going up the stack. The point was that there could be a great deal of superheat in steam even in contact with water, as was the case here, and very wide and rapid variations in that superheat. An interesting point in connection with this is that the fittings of cast iron have been in use at least thirteen years, and he had never known one of them to fail. There was one case, or perhaps two, in which the threads on the cast-iron pipes stripped, but he never knew one of them to fail in any other way.

Inquiries from the floor developed that they were 6-inch threaded fittings made of malleable instead of cast gray iron. Mr. Snyder said that he had talked with many engineers in this country and abroad regarding superheat, and they had all told him practically the same thing

that they did not have any trouble. He asked what changes they made in their piping, and they said that they made practically no changes, but put the superheat in without change. If they have a plant erected for the use of saturated steam and put in superheaters, they do not change anything about the piping.

Mr. Hutchison of the Babcock & Wilcox Company said that in the last twenty years that company had not built a cast-iron mud drum bigger than 10 inches in diameter. Twenty years ago they produced 18-inch mud drums ¾ of an inch thick, and sometimes the core shifted. He had known some to fail from external corrosion, but never from anything else. Today they make them of wrought iron 7¼ inches square. He was personally acquainted with about 150 superheater plants in New England. Just about ten years ago the first superheater started in the Atlantic avenue station of the Edison Company, and he had taken pains to find out there had never been a cent's worth of repairs on those superheaters in ten years. If one were to ask him whether he would prefer to make a guarantee on the gage cocks or the superheaters for a term of years, he would say the superheaters.

J. S. Schumaker said that it appeared from the discussion that it made a considerable difference whether the heat is on the outside trying to get in or on the inside trying to get out. In the case of the superheaters no difficulty has been experienced with the fittings, cast iron or otherwise. In the case of the steam-pipe fittings a great deal of difficulty has been spoken of. It seemed to him that it was probably the result of high temperature on one side of the fittings only, while in the superheater itself the temperatures are, to some extent at least, balanced.

W. N. Cargill said that in 1902 or 1904 the company with which he was connected bought 12 or 13 Babcock & Wilcox boilers. In four or five years the cap bolts failed on most of them. In one instance the failure was under steam. Generally, however, the boilers were cold. The bolts broke off short just about where the thread begins and on being analyzed were found to be hard steel. They changed to bolts having the same size threads but turned down to ⅞ inch in the body, with the same nut and cap, and instead of using hard steel, a wrought-iron bolt was used. The first bolts under test broke off short, but the newer bolt broke off near the head. The first bolts give a tensile strength of something like 29,000 pounds; the others broke under a much less load—3000 or 4000 pounds, but sufficient to hold the caps under pressure.

Mr. Brown thought that the substance of all the papers and discussions boiled down to the fact that cast steel will give a more satisfactory performance under certain conditions than cast iron. The company with which he is connected has found it necessary to replace a number of cast-iron fittings where superheated steam is used, with those of cast steel, and the performance of the steel fittings under the same conditions as those under which the cast-iron fittings were working has been satisfactory. They had a large number of other plants where cast-iron fittings are used with saturated steam, but the design of the piping is such that the stresses which are set up on account of expansion and contraction are very much worse than in the system where superheated steam was used; that they had not gotten into any trouble in the saturated-steam system such as they did in the system where superheated steam was used. He thought that the use of cast-steel fittings would be a more practicable and less expensive way of taking care of the conditions which are set up by the use of the superheated steam than the elaborate precautions which will be necessary in the way of expansion joints, etc.

Mr. Van Stone understood from the discussion that most of the expansion had taken place on one side or the other of the fittings. He recalled the fact that the first fitting brought out at the Edison plant was on top of the boiler. It stood vertically and would seem that the temperature on that was uniform all over. Another case at Lynn was that of an angle valve on top of the nozzle of the boiler. In that case the temperature would be uniform. There would be no possible chance for water to collect on one side or other of the fittings. In that case the fitting was found defective. It is not the water line that causes trouble. They had found more cases with vertical pipes and vertical fittings where there was no chance for water to collect than with horizontal fittings.

Cast Iron Steam Fittings

At the recent discussion of the Effect of Superheated Steam on Cast Iron, at Boston, several of the participants spoke of the absence of trouble from the cause in Europe. One mentioned England especially, and said that his information was to the effect that they use the same pipe and fittings for superheated as they do for saturated steam.

That they use the same pipe and fittings for saturated as they do for superheated steam may be a tantamount statement, but it sounds differently when one says it that way.

The following is from the *Mechanical Engineer*, of Manchester, England:

"We have on several occasions commented on the backwardness of American engineering in matters relating to steam-boiler construction; punching in the flat instead of drilling after bending being extensively practised, and cast iron instead of cast steel or wrought steel used for fittings, branches and valve chests, even for high pressures and superheated steam, in cases where it would not be permitted by any responsible boiler engineer in this country. This general ignorance of first-class boiler construction and workmanship is more or less reflected in the unenviable record of explosions which occur in the States, and is amazing to those familiar with the practical immunity from serious disaster enjoyed here, and the precautions in the choice of materials and methods of construction taken to secure it. Cast iron has been discarded by all competent inspecting authorities here for high pressures for at least a quarter of a century even for saturated steam, while for pipes and fittings carrying superheated steam it has never been sanctioned. Its unsuitability for steam pipes, fitting branches, or riveted mouthpieces attached to boilers or otherwise subject to stress was demonstrated in a series of hydraulic bursting tests made with a full-sized Lancashire boiler by the Manchester Steam Users' Association in the early seventies. The tests were instructive, and it may be useful to recall the results. The boiler was 7 feet in diameter, made of iron plates 7/16 inch thick, double riveted, and was such as was in those days considered suitable for a working pressure of 75 pounds on the inch. At that time many boilermakers made all the fitting branches and mouthpiece of cast iron, although wrought iron was usually insisted upon for the manhole mouthpiece by inspecting companies in boilers constructed under supervision, and there was a widespread opinion that wrought material should be used instead of cast for the smaller fitting branches also. The tests showed that this opinion was fully justified, for a single-riveted cast-iron mouthpiece 16⅝ inches in diameter of the type usually applied burst at 200 pounds on the inch, while the double-riveted seam of the boiler shell withstood 300 pounds, and even the single-riveted seam did not burst until 275 pounds was reached. In other words, one-third the strength of the boiler was sacrificed by using a cast-iron mouthpiece. This result was confirmed by other tests with the cast-iron riveted branches attached to the shell for the stop valve and blowout tap. The former, which was 7 inches in diameter (the opening in the shell being 10⅜ inches), gave way at 275 pounds on the inch, i.e., was only equal in strength to the single-riveted seam; while the latter, with an opening in the shell of only 8¼ inches, failed at 295 pounds—still less than the strength of the double-riveted seam. On the other hand, a double-riveted wrought-iron manhole mouthpiece attached to the shell safely withstood all the tests. When the results of these experiments became known, cast

iron was generally discountenanced by British engineers not only for boiler mouthpieces and attachments, but also for steam pipes and valve chests, except in the case of low pressures.

"Apart from its structural weakness, cast iron is liable to inherent stresses and defects as a result of impurities and bad workmanship in the foundry, shifting of cores, unequal cooling, etc., and it is difficult to detect these defects afterward. Fitting branches may be seriously stressed if the rivet holes are not fair or if the curvature of the flange does not agree with that of the boiler, and those stresses again are impossible to estimate when the attachment is in position. With superheated steam additional objections arise owing to the greater ranges of temperature and corresponding movements caused by expansion and contraction. It is not surprising therefore that cast iron for superheating apparatus has never been sanctioned by responsible engineers in this country. In the United States it would appear that not only is cast iron extensively used for such apparatus but that the causes of its failure are regarded as a matter for discussion and argument. Professor Hollis, for instance, recently introduced a paper before the American Society of Mechanical Engineers with the observation that 'The failure of a number of cast-iron fittings in use with superheated steam has rightly created a widespread suspicion of this material when exposed to high temperature,' and continues with the amazing statement that 'on this subject there is very little information of a character to justify the wholesale substitution of steel castings for the ordinary heavy cast-iron fittings.' We were inclined at first to think that the author's ignorance of good boiler practice was perhaps alone accountable for such a remarkable statement, but he proceeds to say that the doubt as to the reliability of cast iron has seemed to spring up with its use in long pipe lines to steam turbines where the temperature has ranged from 550 to 600 degrees.' As proof of this he instances the troubles experienced in the Edison power station, in which a Curtis turbine was installed—and which may therefore be taken as a modern specimen of American power plant—where the cast-iron pipe line, 14 inches in diameter, was used with cast-iron fittings for a pressure of 175 pounds, superheated to the extent stated. It will not surprise engineers here to learn that troubles arose, and that the cast-iron fittings had ultimately to be replaced with steel fittings. We are astonished that any responsible engineer should for a moment, with the experience available regarding cast iron, contemplate its use in such an equipment. Surprise is not diminished by Professor Hollis' final conclusion that 'it would generally be wise to replace cast-iron tees with cast steel' because 'it is cheaper to do this than put in expansion joints.' 'The unreliability of cast iron,' he finally observes, 'has nothing to do with the case; it is merely that the design usually adopted for steam piping does not quite fit cast iron.' If this opinion is generally held by American engineers regarding the use of cast iron in boiler installations for high-pressure superheated steam, we are sorry for those who run the daily risk of working them.

"Two other papers presented to the December meeting of the American Society of Engineers will, it is hoped, be read, as some antidote to the opinions enunciated in the paper we have just discussed. Professor Miller, for example, describes some experiments made by him to determine the effect of superheated steam on cast iron, 'gun iron,' and steel, and without going into minutiæ, it may be here stated they confirm all past experience, viz., that cast iron is not a suitable material. This is also corroborated by the author of the third paper, Arthur S. Mann, who, however, while admitting that 'ordinary cast iron' is unsuitable still thinks 'gun iron' (a term apparently used in the States to designate a grade of cast iron having a tensile strength of about 30,000 pounds) suitable for steam at 180 pounds pressure with 300 degrees of superheat. He refers also to the particularly deteriorating influence of silicon in cast iron when subject to high temperature, a point which it will be remembered formed the subject of a paper by Messrs. Carpenter and Rugan at the last meeting of the Iron and Steel Institute, and to which we referred in our issue of November 5 (see page 565 ante). Mr. Mann reveals, however, the typical ignorance of American engineers respecting modern European boiler practice, for he quotes a reply to inquiries made on this side, to the effect that steel is not used for superheated work, and follows this erroneous statement with the remark that 'it is not his intention to state that steel of good quality will not do for superheated work,' and follows this doubting admission of the merits of steel by a plea for what he terms 'gun iron,' which is merely a good grade of cast iron, and, apart from its superior tensile strength, retaining all the objections to that material for boiler work. 'Some manufacturers,' he hesitatingly observes, 'are putting on fittings of open-hearth steel which are doubtless good, but,' he continues, 'any foundry can make gun iron if it will, and delay and uncertainty will be decreased by its use,' and thus even the merits of 'gun iron' are reduced to a question of convenience rather than of safety. This is typical of a great deal that relates to boiler practice in the States, which we again assert is in many directions a quarter of a century behind this country."

A Few Pointers on Compression

By A. C. Waldron

That there has been enough written on compression no one will deny, and it would seem that there is nothing new or interesting left. However, I found valuable facts in certain tests to determine whether compression was desirable or not. The plant contained a 6x18-foot boiler, and a 16x48-inch engine.

The test was as follows: The fire was drawn Saturday noon, with steam at about 80 pounds. On Sunday at 2 p.m. I found it at 40 to 50 pounds. I did not touch anything connected to the boiler except to open the water glass. Then I blew the boiler down to 10 inches of water, this being the quantity of water with which each test was started. I started the engine as usual, then, with watch in hand, noted the time that the engine pulled the steam down to 33 pounds, and started my test from that moment, counting the revolutions and noting all other conditions.

Test No. 1. With Compression.
Steam pressure, 33 pounds; 10 inches of water in the glass.
The engine ran 1 hour 34 minutes and made 3522 revolutions.
The valves stopped cutting off after 69 minutes.
The engine ran until steam got to 4 pounds, when it stopped.
It lost 4¼ inches of water in the gage glass.
It took 27 minutes to lose 10 pounds of steam, from 33 to 23 pounds.

Test No. 2. With Compression.
Steam pressure, 33 pounds; 10 inches of water in the glass.
The engine ran 1 hour 34¼ minutes and made 3527 revolutions.
The valves stopped cutting off after 69½ minutes.
The engine ran until the steam got to 4 pounds, when it stopped.
It lost 4¼ inches of water in the gage glass.
It took 27½ minutes to lose 10 pounds of steam, from 33 to 23 pounds.

Test No. 3. With No Compression.
Steam pressure, 33 pounds; 10 inches of water in the gage glass.
The engine ran 1 hour 21 minutes and made 3479 revolutions.
The valves stopped cutting off after 62½ minutes.
The engine ran until the steam got to 4 pounds, when it stopped.
It lost 4½ inches of water in the gage glass.
It took 24 minutes to lose 10 pounds of steam, from 33 to 23 pounds.

Test No. 4. With No Compression.
Steam pressure, 33 pounds; 10 inches of water in the gage glass.
The engine ran 1 hour 22 minutes and made 3484 revolutions.
The valves stopped cutting off after 64 minutes.
The engine ran until the steam got down to 4 pounds, when it stopped.
It lost 4½ inches of water in the gage glass.
It took 23½ minutes to lose 10 pounds of steam, from 33 to 23 pounds.

The four tests required four different Sundays. Conditions were the same at each test, regarding the load. There was a friction clutch between the engine and factories, which I pulled out, leaving nothing but the engine and jackshaft connected. The water level at each test started at the same point, and there was no fire.

The data obtained are shown in test records 1, 2, 3 and 4. Fig. 1 is not from the cards taken with this test, except that the compression shown represents the compression carried in each test. Each test showed about the same result, and

in each case the engine ran thirteen minutes longer than with noncompression. Also, the engine continued cutting off six minutes longer than with noncompression. In each case the engine stopped when the gage showed four pounds of steam. The amount of water consumed in the glass seemed to be about the same in each case, or 4½ inches. It will be noticed that 10 pounds of steam, from 33 to 23, lasted 23½ minutes in the noncompression test, while in the test with compression it lasted 27½ minutes.

These tests all show that the engine takes less steam per stroke with compression, making it run longer with compression, the clearance space being filled with exhaust steam instead of live steam, as in noncompression.

Another holiday I determined the difference in cards taken with and without compression. It differed somewhat from the former tests, "in that the first four tests were simply to show the effect of compression and how long a given quantity of steam would last, with the engine running alone. The steam pressure was lowered to suit the case." But in the present case (see Fig. 1) I carried the regular steam pressure. I also had the factories friction load of 40 horsepower. Now, this load was positively the same all the time, because I was sure no person was in the shops at the time to add to or take from the load. In this test I took 60 cards, 30 with compression; then I simply changed the exhaust valves and took 30 more without compression. Going over each card with a planimeter, I found that the average area of the noncompression card for one revolution was 4 square inches, and that of the compression cards was also 4 square inches for one revolution.

Then I took two cards whose areas were the same in square inches and placing their back-pressure lines together, as shown in Fig. 1, we have the results. The full-line card shows slight compression, and the dotted lines show the compression as carried in the test; also the increase in cutoff due to compression. From the first sight of Fig. 1 we would say at once that it is not economical to have compression because of the increased cutoff shown by the dotted lines. Let us assume to have 7 per cent. clearance and a 48-inch stroke. If the engine cuts off at 9⅗ inches, it would have an apparent cutoff of

$$\frac{9\frac{3}{5} \times 100}{48} = 20$$

per cent. for the full-line card with no clearance, and a real cutoff of

$$\frac{(20 + 7) \times 100}{100 + 7} = 25\frac{5}{21}$$

per cent. when considering the clearance space.

Now, for the dotted-line card cutting off at $10\frac{7}{16}$ we have for an apparent cutoff with no clearance

$$\frac{10\frac{7}{16} \times 100}{48} = 21\frac{3}{4}$$

per cent., and a real cutoff of

$$\frac{(21\frac{3}{4} + 7) \times 100}{100 + 7} = 26\frac{19}{21}$$

per cent. It is evident here that we have nearly filled a 7 per cent. clearance space at the expense of 1.73 per cent. increase in the real cutoff; hence the reason for the engine running a longer time in the former tests with compression. A glance at the leaning admission line on the full-line card, with no compression, will illustrate another reason why the maximum output and range of cutoff is decreased by carrying no compression. As the admission line at *X*, Fig. 1, is not perpendicular, it shows that the clearance space did not have time to get filled until the piston got started on its stroke; and it is also plain that if we would have a perpendicular steam line we must put the eccentric farther ahead and by this act we will surely decrease the range of cutoff, or maximum output of the engine. The dotted-line card having compression shows that the clearance space was filled at the beginning of the stroke and almost entirely with exhaust steam, and the eccentric was not disturbed in either case.

On the other hand, the dotted lines (Fig. 1) show an increase in the cutoff of 1.73 per cent., which we must admit is caused by adding compression, but the two latter cases are not similar in character, in that the first case, of no compression, the maximum efficiency is decreased and it gives nothing in return to compensate for it, such as filling the clearance space with exhaust steam as in the case of the dotted card, or even quiet running; whereas in the case of the compression card the cutoff is increased but the saving in clearance due to compression more than offsets it. It cannot be denied that compression decreases the maximum output of the engine. That this is true will be shown here.

Suppose we have an engine that is carrying its ultimate capacity on a fixed cutoff and given steam pressure with no compression; then suppose we add compression; the engine will at once try to let out on its cutoff, as shown in Fig. 1, but as it has a fixed cutoff it cannot do it and the natural result is to decrease its revolutions because the mean effective pressure would be decreased to that due to the rise in area of the compression line. Consulting a table on mean pressures per pound of initial with different clearances and points of cutoff we will find that for an engine having no clearance and an apparent cutoff of 0.25, the mean pressure is 0.5966 per pound of initial; while by adding 7 per cent. clearance the real cutoff would give 0.6359 pound per pound of initial, an increase in available energy of 0.0393 pound, due to adding clearance and having no compression; and it would give a greater volume of steam at cutoff and consequently the expansion line would be higher due to this greater volume and increased initial pressure.

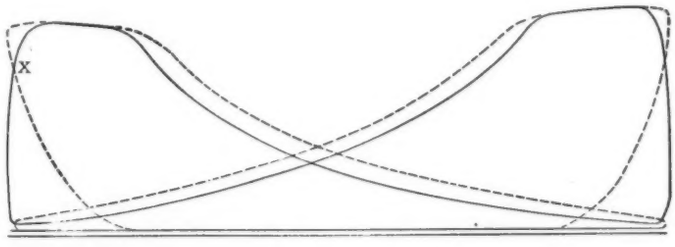


FIG. 1

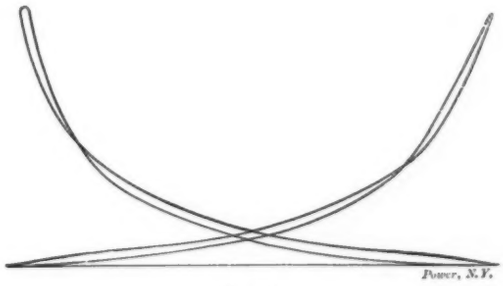


FIG. 2

But it will be found that the maximum output is decreased because of the compression, but the economical advantage is plainly seen by the real and apparent cutoff.

Fig. 2 shows an example of high compression at light loads, and yet the cutoff shows scarcely enough to run an engine with no resistance at all. Now, Fig. 2 is an exact duplicate of a card from a high-speed engine with a friction load, using a shaft governor. This card is printed in a certain well known engine builder's catalog, and is published as an example of perfect steam distribution, and low water consumption per horsepower, notwithstanding the high compression.

It is an established fact, also, that with gas engines, high compression is more economical than low.

If a lubricator glass gives trouble by clogging, fill it up with vinegar, or put a little piece of soap in it.

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The Marine Engine of the Future

In the Gas Power Department of this issue will be found an interesting letter on the above subject, which, however, indicates that the writer thereof has not given adequate consideration to all sides of the question. To begin with, Mr. Stilz apparently overlooks the fact that by the use of electric transmission between the turbine and the propeller each can be run at its best speed, the propeller speed can be varied over a wide range and its direction reversed with unprecedented celerity and facility, and the total weight of the entire power plant made *less* than that of a straight turbine-propeller equipment. The argument that low efficiency at light loads is a serious handicap to a marine turbine has no merit whatever; when do the turbines of ocean steamships, or even river steamers, run at light loads? But admitting, merely for the sake of argument, that light-load efficiency is important, this condition is easily met by the use of several generating units, as in central-station work. As a matter of fact, however, the question of efficiency at light loads is practically negligible, because light loads occur only under unusual conditions or for short periods.

Mr. Stilz's position as to the boiler plant is more tenable, but his argument for the constant-pressure engine working with liquid fuel has several points of weakness, the most serious of which is the failure to recognize the fact that all of the oil produced throughout the world is insufficient to furnish motive power for all the transatlantic and coastwise ships entering American harbors, not to mention those on the Pacific, the Great Lakes, and the rivers, and those which do not enter ports in the United States at all. This, of course, forces the transfer of Mr. Stilz's advocacy to the producer-gas engine as the predominating type of the future, and it is not at all impossible that his prognosis is right in general, although his reasoning is not flawless in detail. For example, it is not true that the treatment of the cylinder wall with regard to the heat developed inside it is diametrically opposite in a gas engine and an air compressor; on the contrary, it is exactly the same in kind in both cases, differing only in degree—less heat needs to be abstracted from an air-compressor cylinder than from a gas-engine cylinder of the same power, but heat must be taken out of both. The fallacy that outside compression is much more economical than using the power cylinder of a gas engine to compress the charge has been exploded long since; the chief advantage of the two-stroke over the four-stroke cycle is the gain of one hundred per cent. in power impulses per revolution, not improved efficiency due to external pumping.

The chief opportunity to improve the efficiency of the internal-combustion engine lies in the direction of increasing the temperature range by extending the expansion line. The existence of "diametrically opposite conditions within the same cylinder" is at its worst during the power stroke only; at the moment of combustion it is desirable to extract the maximum quantity of heat from the cylinder contents, whereas, after the contents have been cooled to within lubrication limits by expansion, it would be nice if the extraction of heat could be stopped short and all of the remaining heat utilized by extended expansion. So far, this method of cooling is impracticable, but the larger utilization of the available heat has been accomplished, of course, by the well known expedient of taking in less than a cylinderful of mixture during the suction stroke and thereby reducing the pre-compression pressure and, consequently, carrying the expansion of burned gases much nearer to atmospheric pressure than is ordinarily done. The arrangement produces a cooler-running engine and higher indicated kinetic efficiency, as compared with unrestricted intake and higher release pressure, but entails the use of a larger and therefore heavier engine for a given output, because less mixture is taken in per cubic foot of piston displacement.

We share Mr. Stilz's enthusiasm over the possibilities of the external-compression engine giving an indicator diagram which has a steam-engine admission line, though we cannot approve most of his reasoning. Such an engine working, of course, on the two-stroke cycle, seems inevitable in due course of development, and it will find an enormous field when it comes, but we are not rash enough to agree that it will drive everything else out of the marine field; moreover, whatever success such an engine may have will be due not to any increase in efficiency due to external pumping, but to the flexibility of control and the divorce of the compression and expansion ratios made possible by external compression.

Mechanical Power on the Farm

The United States Department of Agriculture has been conducting a campaign of education about the possibilities of applying power to the work of the farm. The loneliness of the isolated homestead has been greatly mitigated by the rural telephone and its wide-spread party lines; if the severity of the physical labor in tilling the soil can be also lightened by the use of mechanical power, the two greatest factors in deterring the citizen from the healthful outdoor life of the farm will have been eliminated.

At a recent gathering of engineers in New York City, one of these lectures* discussed the transformations now in progress through the district of large farms in a popular and interesting way, but did not enter into the quantitative values of either the magnitudes or the cost of such power units.

The farm acre is ten square chains. The surveyor's chain of 66 feet in length when squared gave 484 square yards; or the acre contains 4840 square yards. This is a square of 208 feet on the edge. A plowman walking behind his plow on such a square acre, will therefore have walked a mile when he has turned 5280 $\div$ 208 = 25 furrows. If the furrow is shallow, as turned by two or three horses, they will be about one foot apart; or the whole acre will have compelled him to walk 208 $\div$ 25 = 8 miles, using round figures. With the time lost in turning at the ends; the slow pace of man and beast over the rough ground, the heavy duty of the traction and the necessity to rest the team in the middle of the day, the traction output for a ten-hour day is limited to about one acre. This is the basis of a figure of some acceptance that ten horsepower-hours go to the plowing of one acre. When the ground is at all heavy, it is a low figure that fixes the cost of such plowing per acre at $1.50. There are many quantities which are hard to fix and evaluate, such as the deterioration of the horse itself, the waste of unproductive feed and housing and warming in winter, the price of labor for such winter care and upkeep and repairs to the living organism. Furthermore, the horse cannot be left in the field over night where his work has been today and is to be tomorrow, but the time lost in going and coming must be added in.

If in addition to the plowing units of output there be added the power used in seeding, cultivating and harvesting, the consumption of horsepower in the farming sections of any large country like the United States or in the southern countries of this continent, the total becomes startlingly large. Quite usual figures of computation place the horsepower output on the farms as over forty millions.

If now on the other hand, mechanical power be substituted for horses in the form of tractors, a number of the limitations of the horse as a source of power are eliminated. The greatest number of horses which one man can effectively control and plow at the same time is five. These will drive or haul one plowshare attached to a wheel plow, where the driver can sit and be borne along with it. Two horses is a handful when the plowman walks behind it and guides and controls it by his hands. With a mechanical tractor, however, multiple plow surfaces can be propelled, from four to eight shares in action at once, and at a speed possible only to a motor which knows no fatigue. The farmer can thus utilize weather conditions favorable to his work, and if necessary, one motor can work in double shifts. If the tractor be designed to exert the power of one hundred horses and the work of plowing one acre required a five-horsepower team, then with multiple or gang plows, a capacity of twenty acres per day should be secured, with the labor of two men.

Shall the tractor be a steam-engine and boiler combination, or is this a case where the liquid-fuel internal-combustion engine has the call? In many parts of the great West, the problem of supplying water to the steam boiler will be the governing factor. It often requires nearly as many horses to haul the water and solid fuel for the engine as the engine is expected to displace in doing the work of plowing. Here the self-contained oil engine, using either alcohol, kerosene or gasolene, is plainly suggested; and this may almost be called the general case. By eliminating the boiler, excessive weight on the wheels is avoided, and a more equable distribution of wheel load is possible, with adequate pressure for traction on soft and uneven ground.

Then finally, what are the economic possibilities of such power traction? If the first cost of such a tractor be called $3000, and its life be called eight or ten years, in each of which it could be operated from 100 to 125 days, then its service of 1000 days should be charged with one-thousandth of its cost at the rate of 3000 $\div$ 1000, or $3 per day for depreciation. Interest in its cost is $150 per year, or fifty cents per day. Repairs at two per cent. of its price would be twenty cents. Lubrication at $100 per year would be thirty cents per day. Freight charges and sundries $150 per year, or fifty cents per day. The labor cost on the field will be the engineer at $3.50 and the helper on the plow deck at $1.50, or $5 in all. This includes everything except the uncertain fuel cost variable with the work done and resistance overcome. If the motor is run with gasolene at twenty cents a gallon, and sixty gallons per day are required, the fuel cost will be $12. If a cheaper fuel such as kerosene is permissible, at twelve cents or less per gallon, the cost is cut to $7.20. Calling it $9 as an average or mean, the total cost becomes:

Fuel per day per 20 acres	$9.00
Labor per day per 20 acres	5.00
Lubricant per day per 20 acres	0.30
Repairs per day per 20 acres	0.20
Interest per day per 20 acres	0.50
Depreciation per day per 20 acres	3.00
Freight and sundries	0.50
Total cost per day per 20 acres plowed	$18.50
Total cost one acre plowed	0.92

This is about two-thirds of the cost of animal motors for the same work done; and all the additional advantages of lightened toil for the men, diminished expense of maintenance when idle, and much more economical storage are derived beside. It would seem a safe prophecy to make that such substitution as outlined in the foregoing is sure to be made on the farms of large area in the very near future. When it does occur the spread of interest in the power plant, its needs and its possibilities will be extended to a new area, and the engineer will become more and more the principal factor of the community.

*"The Era of Farm Machinery," by L. W. Ellis, Bureau of Plant Industry, before the thirtieth annual meeting of the American Society of Mechanical Engineers.

An Omission

In the article by Frederick Ray on a Condensing Plant of Novel Design, which appeared in the January 4 number, the following paragraph was inadvertently omitted:

"The contract for the condensing equipment as a whole was taken by the Alberger Condenser Company, the piping and all other work being done by the Bethlehem Steel Company. The centrifugal pumps and return-water turbines were furnished by the contractor. Henry Grey & Son were the consulting engineers for the whole Saucon plant and it was due largely to their progressiveness that the scheme, which was the suggestion of the writer, who also designed the pumps and return-water turbines, was adopted."

It is always our policy to give credit where credit is due, and we greatly regret the omission of the above paragraph, which was wholly unintentional.

The city of Chicago is discussing the possibility of utilizing the water power obtainable from the Drainage canal to extend the street-lighting system. A large part of the city is illuminated with gas and gasolene lamps, but by making use of the power from the Drainage canal these lights could be replaced with electric arcs. There are 13,000 arc lamps now in use, and if the gas and gasolene lamps are done away with, 29,000 arcs will be required.

NEW·POWER·HOUSE ·EQUIPMENT·

What the Inventor and the Manufacturer is doing to save time and money in the Engine Room and Power House

The De La Vergne Type FH Crude Oil Engine

The accompanying engravings illustrate the latest type of horizontal crude-oil engines, built by the De La Vergne Machine Company, foot of East One Hundred and Thirty-eighth street, New York City.

The engine works on the four-stroke cycle and is of the single-acting single-cylinder design, as indicated by Fig. 1, which shows the engine built for belt drive. Both inlet and exhaust valves work in a cage set in the cylinder head, as shown in Fig. 2, which represents a cross- and horizontal-sectional view of the cylinder. The air-inlet and exhaust valves are operated by rocker arms and a cam shaft, driven by means of skew gears from the engine crank shaft. This cam shaft extends along the lower portion of the engine frame, as shown in Fig. 1. The action of both air-inlet valve and exhaust valve is positive at all portions of the stroke and at all loads.

The stability and compactness of the frame design is shown in Fig. 1, the frame and the water-jacketed cylinder being cast in one piece. The crank shaft is of the center-crank type and is supported by a bearing at each side of the crank, besides an outboard bearing on the outer side of the flywheel.

The cylinder head contains the valves, combustion chamber and valve gear, and is bolted to the cylinder as shown in the several illustrations. The sectional view, Fig. 2, shows the general design and arrangement of the inlet air valve, exhaust valve, vaporizing chamber and oil-spray nozzle and valve. The inlet air valve and exhaust valve are seated by means of springs, as shown, the opening of each valve being timed by a cam on the cam shaft, which transmits motion by means of rocker arms. These valves open direct into the combustion chamber, which is placed crosswise of the cylinder, as shown at *A*, an end view also being shown.

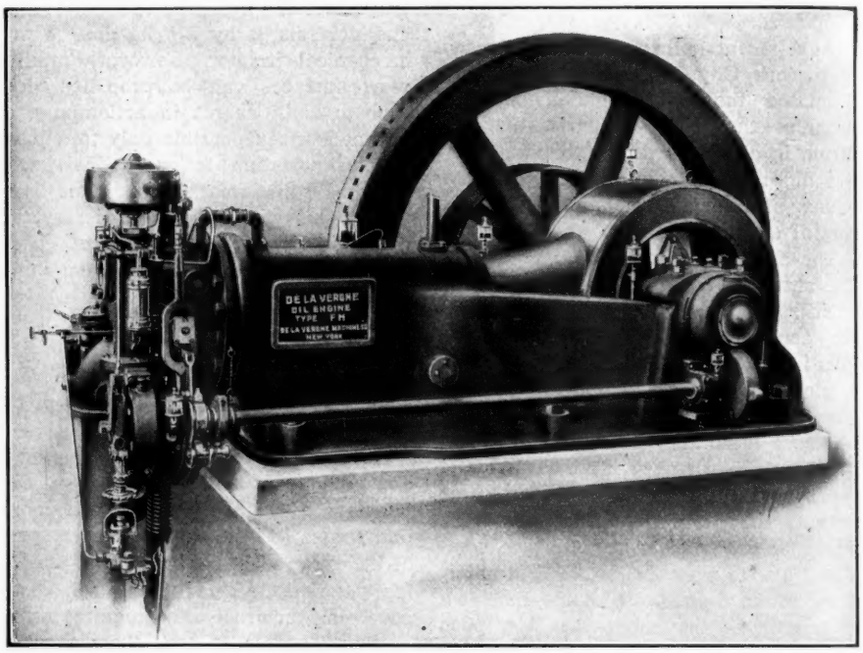


FIG. 1. GENERAL VIEW OF NEW DE LA VERGNE CRUDE-OIL ENGINE

At one end of the combustion chamber is attached a vaporizer cap which is ribbed, as shown in Fig. 3. In the inner end are inserted the oil-spray nozzle and needle valve, shown in Fig. 4. The vaporizer consists of a rough gun-iron casting, into which the fuel is directly injected. The sprayer or oil-inlet valve is simple in construction, consisting of but few pieces, and can be easily taken apart for cleaning, if necessary. It is stated, however, that owing to the perfect combustion of the fuel in the vaporizer and cylinder it is not necessary to remove the vaporizer at any time, and that the spray-valve nozzle requires cleaning only after long periods of use.

The oil-spray nozzle consists of a chamber *A*, Fig. 4, or valve body having a comparatively large hole through which the oil is injected to the cylinder; *C* is

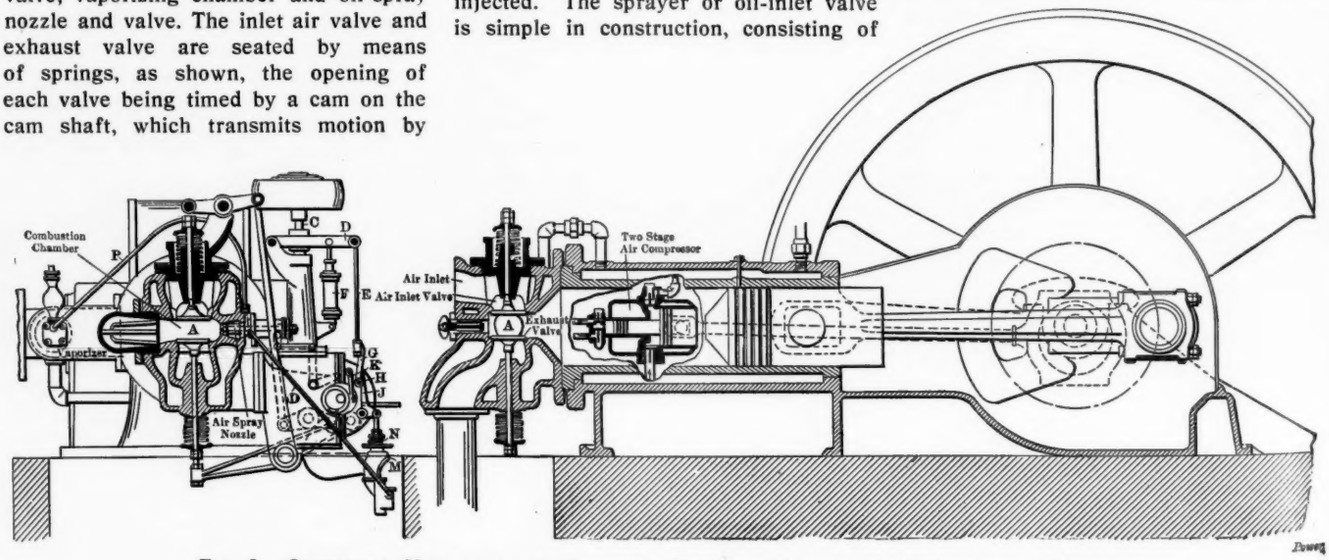


FIG. 2. SECTIONAL VIEWS OF THE CYLINDER SHOWING VALVES AND COMBUSTION CHAMBER

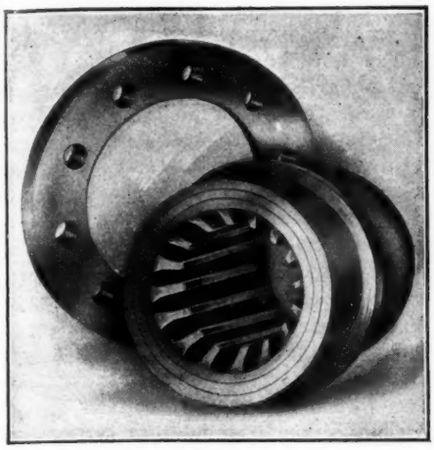


FIG. 3. VAPORIZER CAP

a needle-valve spring which holds the valve in place and *B* is an atomizer, being made with several grooves which cause the oil and air to mix as they pass the sleeve along the outside. This sleeve fits onto the small end of the needle valve and the whole is placed in the casing *A*.

The compressed air used in the spray-valve nozzle is furnished by means of a small two-stage air compressor, which is bolted direct to the engine frame, as shown in Fig. 5. The compressor is driven by means of an eccentric and rod from the main crank shaft. Fig. 5 also shows the starting device, vaporizer and governor.

Fig. 6 shows another view of the governor, air pumps and valve mechanism. The office of the governor is to regulate the stroke of the oil pump. A study of

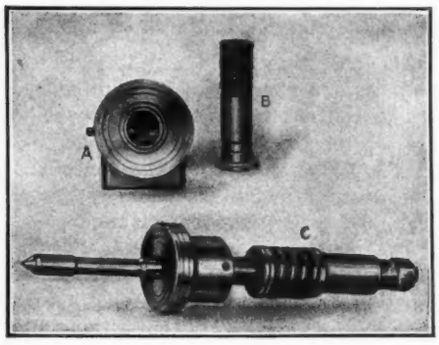


FIG. 4. OIL-SPRAY NOZZLE

Fig. 2, end view, and Fig. 6 gives a very comprehensive idea as to how this is accomplished. Referring to Fig. 2, end view, it will be seen that the governor spindle *C* imparts motion to the arm *D*, which is pivoted at one end and supports the rod *E* and a rod running to the dash-pot *F*, the latter being used to secure steadiness of governor operation. On the lower end of the rod *E* is secured a finger member *G*, in which is fitted a roller *H*. This finger with its roller, hangs suspended between the levers *J* and *K*, the former being attached to the piston of the oil pump *M*, the latter bearing against the eccentric shown. The spring *N* keeps the arm pressed against the roller *H*; hence, there is no lost motion and noiseless operation is secured. As the governor causes the arm *D* to rise and fall, the roller *H* will change its position, either up or down, which produces the same effect as if the length of the levers *J* were lengthened or shortened; thus increasing or decreasing the length of the oil pump's piston stroke. The oil is forced to the spray nozzle through the pipe *D*, while the air enters the nozzle through the pipe *P*.

The engine operates in the following manner: On the first outward stroke of the piston, air is drawn into the cylinder through the air-inlet valve located on top of the cylinder (see illustrations). On the next stroke of the piston, or first inward stroke, the air previously drawn

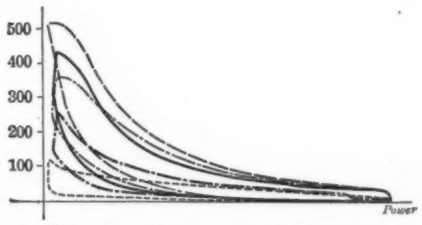


FIG. 7. COMBINATION DIAGRAM

into the cylinder is compressed and forced into the space between the air and exhaust valves and vaporizing chamber *A*. As the process of compression is completed, fuel is injected by means of compressed air into the vaporizer chamber, which is made pear-shaped to correspond with the formation of the spray or jet of oil as it leaves the spray nozzle. The heat generated by the compression of air in the cylinder, together with the heat furnished by the heated walls of the vaporizer, causes ignition. On the third and outward stroke the impulse is obtained, which stroke is followed by the fourth and last stroke of the cycle, during which period the products of combustion are ejected from

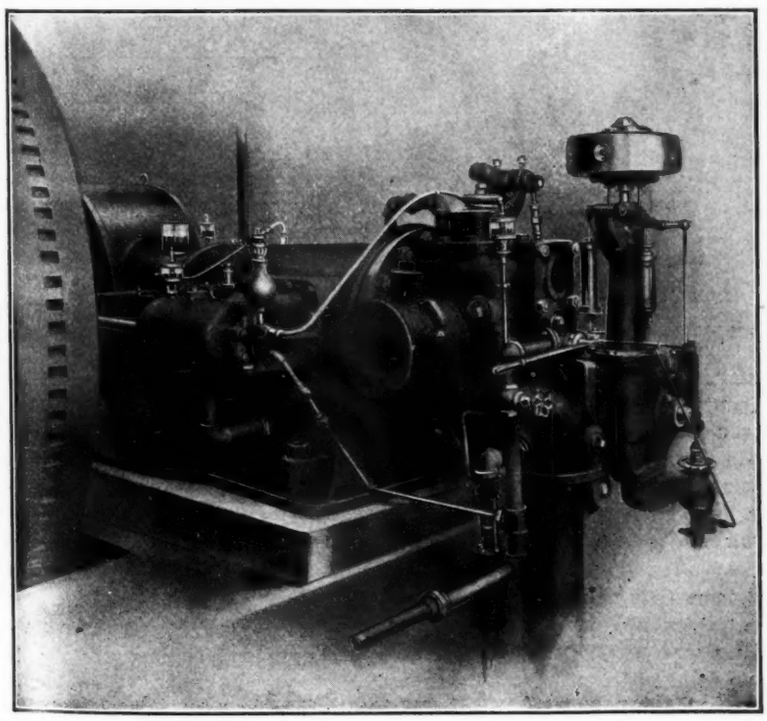


FIG. 5. SHOWING COMPRESSOR FOR SPRAY VALVES, STARTING DEVICE AND VAPORIZER

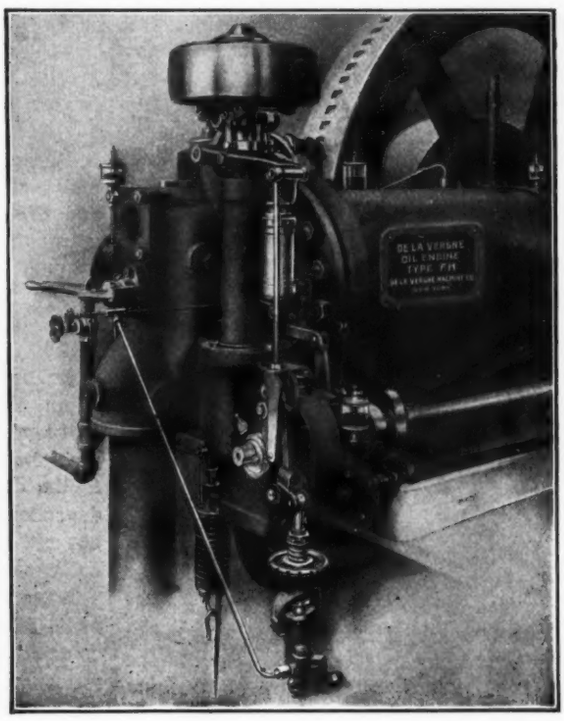


FIG. 6. GOVERNOR, OIL PUMP AND VALVE MECHANISM

the cylinder and vaporizer through the exhaust valve.

Before starting the engine, the vaporizer is heated by a blast lamp designed for that purpose. This lamp reaches up through the opening in the bottom of the casing cover covering the vaporizer, the cover being shown in Fig. 5. It requires about two minutes to properly heat the vaporizer, after which a charge of fuel is injected into the vaporizer by hand and the engine put in motion by means of compressed air. This is accomplished by opening a valve in the head, by means of the lever shown in Fig. 5.

This engine embraces features which have already proven successful in other engines, such as the use of the vaporizer, which is similar to the one used with the Hornsby-Akroyd oil engine, such as pressed air to atomize the oil, such as is used in the Diesel oil engine, the peculiar feature of this engine, however, being the pear-shaped combustion chamber to conform to the form of the spray jet as it emerges from the spray nozzle.

In Fig. 7 is shown a combination of diagrams from various oil engines, the diagram designated by the heavy lines being the one taken from this engine, which shows that the compression is 400 pounds per square inch. Under working conditions the compression averages 300 pounds per square inch. The oil consumption per brake horsepower is from 0.4 to 0.45 pound per brake horsepower-hour, it is stated. An installation for Snead & Co.'s iron works, Jersey City, N. J., recently ran 162 hours, developing 5290 kilowatt-hours, and using 632 gallons of oil at a cost of 2¼ cents per gallon, making the fuel cost 0.27 cents per kilowatt-hour.

These engines are built in sizes from 85 to 350 horsepower, with both single and duplex arrangement of cylinders.

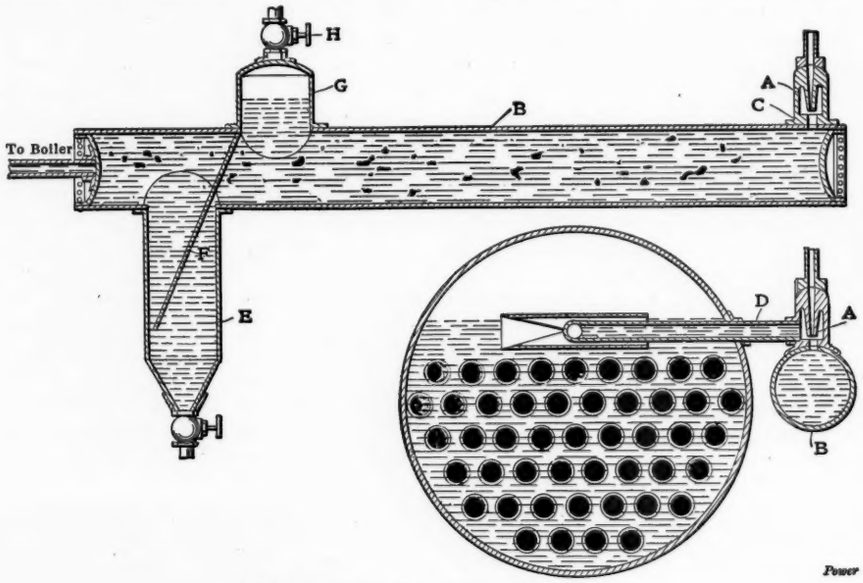
A Mechanical Feed Water Purifier

The object of this device is to purify feed water before it is introduced into a boiler, and largely, if not wholly, prevent the formation of scale. The device is placed adjacent to the boiler, and hot water is admitted under pressure from the feed pump or injector.

The manner of operating the purifier is as follows: When the injector or pump is started, the feed water is forced through the nozzle *A* in the injector into the receptacle *B*, through the discharge *C*. At the same time hot water from the boiler is drawn through the pipe *D* and forced through the discharge *C* into the receptacle *B* along with the cold water. The hot water in passing through the discharge *C* is intermingled with the cold water discharged through the nozzle *A*. The cross-sectional area of the receptacle *B* is considerably greater than the combined cross-section of pipes *C* and *D*, and the contents of the receptacle are substantially at rest while passing through it, there being a slow current toward the discharge end of the boiler when the injector or pump is working.

As the water is in a highly heated condition, the matter or substance desired to be removed from the boiler will be precipitated in the receptacle *B* and well *E*, the deflector plate *F* causing it to be deposited in the well from which it can be withdrawn by opening the blowoff cock.

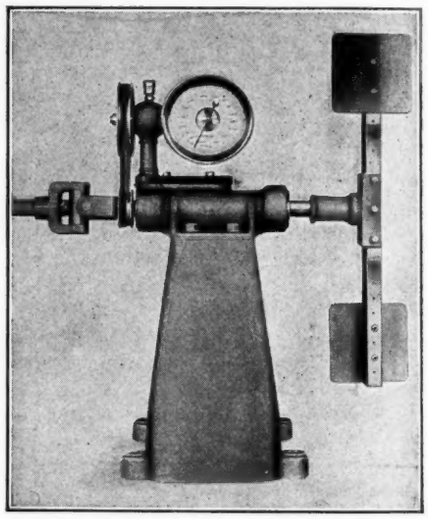
When the dome *G* is used, substances of less specific gravity than the liquid content of the receiver *B* will be collected in such dome and can be removed by opening the blowoff cock *H*. This device is manufactured by E. P. Monroe, 1017 West North street, Chicago, Ill.



MECHANICAL FEED-WATER PURIFIER

A New Fan Dynamometer

The fan dynamometer shown in the accompanying engraving has been placed on the market by Joseph Tracy, 116 West Thirty-ninth street, New York. It consists essentially of a metal standard carrying a horizontal steel shaft in large ball bearings; one end of this shaft is connected to the motor under test by a universally jointed extension shaft and the other end carries an overhung two-bladed fan, as shown. From a small pulley on the dynamometer shaft a belt extends to a larger pulley on the spindle of a special tachometer which is mounted on top of the housing that carries the dynamometer-shaft bearings. The tachometer is provided with a double scale, the inner scale showing the revolutions per minute and the outer scale the horsepower developed. The speed scale is graduated in divisions of 20 revolutions from 200 to 2000 revolutions. The horsepower scale gives a minimum reading of one horsepower at 480 revolutions and a maximum reading of 70 horsepower at 1980 revolutions. Consequently at all ordinary rates of motor speed a simultaneous reading of revolutions per minute and horsepower can be obtained without any computation.



TRACY DYNAMOMETER

This dynamometer can be used for testing engines, motors, etc., on the block by making suitable connection between the free end of the dynamometer shaft and the motor shaft. It can also be used to test an automobile motor in position on the chassis by disconnecting the propeller shaft and substituting for it the jointed shaft of the dynamometer.

The standard dynamometer is designed to test motors and engines of medium power, but by using calibrated fan blades of greater or less area, and corresponding tachometer scales, the range of measurement can be varied between wide limits.

INQUIRIES OF GENERAL INTEREST

Questions are not answered unless they are accompanied by the name and address of the inquirer

Heating Surface

What is meant by the heating surface of a boiler and what will be the heating surface of a return-tubular boiler 6 feet in diameter having 150 tubes 3 inches in diameter and 15 feet long?

C. A. M.

The heating surface of a boiler is all of the surface of plates, tubes, drums, headers, etc., on one side of which there is water and on the other side the products of combustion. In computing the heating surface of a boiler, each tube will have a heating surface equal to its outside area. The area of a tube 3 inches in diameter and 15 feet long will be its circumference multiplied by the length; 3 inches is one-fourth of 1 foot and the circumference of the tube will be

$$3.1416 \times \tfrac{1}{4} = 0.7854$$

feet. This multiplied by the length of the tube, 15 feet, will give 11.78 square feet for the heating surface of one tube. For 150 tubes it will be

$$150 \times 11.78 = 1767$$

square feet of heating surface in all the tubes. One-half of the shell is usually reckoned as heating surface. The circumference of a 6-foot circle is

$$6 \times 3.1416 = 18.85$$

feet, and the area of the whole shell would be fifteen times this amount, or 282.75 square feet. As only half of the shell is taken, the heating surface in the shell would be 141.37 square feet. For the back head or tube sheet the total area will be the diameter squared multiplied by 0.7854 or 28.27 square feet; two-thirds of this will be below the deflecting arch and will be equal to 18.85 square feet. From this must be subtracted the area of the ends of the tubes. The end area of one tube is 0.049 square foot and for 150 tubes it would be equal to 7.35 square feet. Then the heating surface of the back head will be

$$18.85 - 7.35 = 11.5$$

square feet. As the front head is not reckoned in computing the heating surface of the boiler, this completes the calculation of the area of the heating surfaces. Adding together these areas,

$$1767 + 141.37 + 11.5 = 1919.87$$

square feet for the heating surface in the boiler; dividing this by 12, the usual allowance of heating surface per horsepower for return-tubular boilers, you will have 159.9, or practically 160, boiler horsepower.

Area of a Segment

On page 6 of the Massachusetts Board of Boiler Rules is a formula for finding the area of the segment of a boiler head to be braced. I do not understand this formula and would like to have it expressed in plain English in the form of a rule.

J. B.

A formula is a short way of stating a rule written out in long hand. The formula

$$\frac{4\,H^2}{3}\sqrt{\frac{2\,R}{H} - 0.608}$$

would read as follows: For the first step, multiply the hight of the segment (less 5 inches) by itself, then by 4, and divide the result by 3. Then for the second step, divide twice the radius (less 3 inches) of the boiler by the hight of the segment (less 5 inches) and subtract 0.608; extract the square root of the remainder. Now multiply the results of the two steps together and the sum will be the area to be braced.

Valve Setting and Injector Troubles

Can you give me simple directions for setting a plain slide valve? The injector on my traction engine works nicely when the engine is standing still, but when on the road, the suction occasionally breaks; what is the remedy for this? How can I tell what the point of cutoff is in an engine cylinder?

J. M.

To set a slide valve, remove the steam-chest cover and loosen the eccentric, turn the eccentric first to one extreme end of its travel and then to the other, and see whether the ports are opened to the same extent. If not, lengthen or shorten the eccentric rod until both ports are opened the same amount when the eccentric alternately occupies its extreme positions. Place the crank on one of the dead centers, turn the eccentric slowly in the direction the shaft is to turn, until the port is opened 1/64 inch. Tighten the set screws in the eccentric, and turn the crank to the opposite dead center and note the lead, which, if unequal, may be equalized by adjusting the length of the stem.

The difficulty with the injector probably is that the jarring while on the road tends to break the suction. See that the injector is clean; a part of the trouble may be due to accumulation of scale on the interior surfaces, especially in the jets and combining tube.

The more reliable method of determining the point of cutoff is to take off the steam-chest cover, place the crank on one of the dead centers and have the engine shaft turned in the direction it ordinarily runs, until the valve opens the port wide and again closes it. The point in the stroke reached by the crosshead when the port is just closed will indicate the point of cutoff. When the initial pressure in the cylinder and the pressure at which the steam exhausts are known, the point of cutoff may be found by first adding 15 to each of these pressures, then dividing the exhaust pressure by the initial pressure; the result is the point of cutoff expressed as a fraction of the stroke.

Horsepower of Water Turbines

Please inform me how to find the horsepower of a water wheel, and is there any standard method of doing this?

T. N. K.

As you have not mentioned the kind of water wheel it is presumed that you refer to the turbine, which delivers from 65 to 75 per cent. of the theoretical power due to the weight and head or fall of water. A fair average efficiency of turbines is 70 per cent. The energy due to a given volume and fall of water is equal to 62.4 Qh and the theoretical horsepower is,

$$H.P. = \frac{62.4\,Q\,h}{550},$$

while the actual horsepower corresponding to an efficiency of 70 per cent. is,

$$H.P. = \frac{62.4\,Q\,h}{715} = 0.08727\,Q\,h$$

in which Q = the volume of water in cubic feet passing through the wheel per second, and h, the head or fall in feet. There is no standard method that is generally adopted because the results vary, with the construction and proportions of the wheel, and for this reason experimenters have deduced a variety of formulas, each of which is well adapted to the construction of wheel experimented upon and in a general way to other wheels of the same type. You will find data and formulas pertaining to the various kinds of water wheels in Weisbach's "Hydraulic Motors."

The Late Joseph W. Thompson

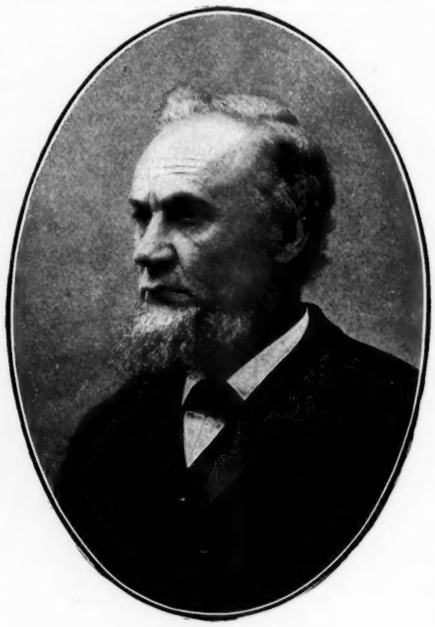
Through the death of Joseph W. Thompson, at Salem, O., July 15, 1909, the engineering fraternity lost another one of those sturdy pioneers who had been prominent in the mechanical development of the past half century, a development which has served to place the United States in the enviable position it holds today in the industrial world.

Mr. Thompson was particularly identified with the development of the high-speed engine industry and was the originator of many devices and features which have since become standard practice in modern steam engineering.

Joseph W. Thompson was born December 23, 1833, in a log cabin on a farm in Columbiana county, Ohio, where he passed the first dozen years of his life. The family then moved to East Fairfield, the same county, going from there to the adjacent county of Stark. His school education was confined entirely to that obtainable at the common district schools of the time, and extremely common they were; but sufficed to enable him to master the "three R's" sufficiently for practical purposes. During this period he went entirely through Ray's arithmetic, which was seldom done in those times. Whatever further education was obtained in later years was self-acquired, as necessity and inclination prompted.

His mechanical education began as crudely and primitively, as to tools and methods. On April 1, 1851, he entered as an apprentice, a small machine shop in Salem, O., conducted by Samuel C. Taylor, assisted by Richard H. Garriques as master mechanic. In this shop there were two lathes of moderate capacity, built on wooden frames to which were bolted flat hand-finished shear pieces. There was a cast gear for both the back gear (under gear in this case) and for screw cutting. The carriages were held down with weights, a lever and weight holding down the tool-jack carriage with added firmness; solidity, freedom from play and simplicity being obtained by the use of the weight without any "gibbing" whatever. The young mechanic could not learn to plane, for there was no planer. Hammer and chisel, the file and the red-chalk straightedge, and in many cases emery grinding, took its place. A crude vertical drill press attached to a low ceiling, a horizontal one on a wooden frame and a grindstone, the latter of much more relative importance than at present, completed the outfit. While he was there a homemade iron-frame lathe was bought, but it was unfinished. It had a powerful live head, highly and strongly geared, and a broad strong carriage gibbed down and the cross feed also gibbed. The lathe, however, had no feed. The carriage was propelled by a rack and pinion without second gear, the propelling crank being fitted to a square end on the pinion shaft; and cast-iron engine shafts, the only ones then used, were sometimes turned by hanging weights on the propelling crank, changing the position of the crank from time to time as required. With this equipment the problem was frequently not only how to make a certain piece of machinery but also how to make a tool to make the piece, and instruction was more often in the line of how not to do a thing rather than how to do it.

There was, at that time, another equally simple, primitive shop in Salem which had been started by Sharp Brothers in 1844. During his apprenticeship the brothers, Simeon and Joel, founded a partnership with Milton Davis and Joel S. Bonsall, and in December, 1851, or-



JOSEPH W. THOMPSON

ganized under the firm name of Sharps, Davis & Bonsall, and built a brick shop of much greater extent and of more modern equipment than the other, in which they engaged in more extensive and systematic manufacture of engines, mostly for flour mills and sawmills; the latter first with "muley" and later with circular saws, direct connected, at high speeds, often between 400 and 500 revolutions per minute, at that time speeds quite phenomenal. After finishing his three years' apprenticeship, he procured work at the new shops of Sharps, Davis & Bonsall, first as a machinist, but later as a designer and inventor of all sorts of machinery and appliances pertaining to engines, engine building and machine-shop work. With one or two brief interruptions, one of which was nine months' service in the Ninteenth regiment, O. V. I., from which he returned through sickness, Mr. Thompson continued with this firm during its existence.

An object lesson which made a great impression upon his mind, and having to do with the engines made by Sharp Brothers, occurred in the late forties, when he was about sixteen years old. At that time he was living in the edge of Stark county, and a mile away a sawmill was built in which a muley saw was driven by belt from an engine. Having a passion for watching machinery, he spent most of his leisure time watching the mill and soon noticed that it slowed down considerably during a cut, and took an appreciable amount of time to recuperate, before the next cut could be made. Considerable solid wood from the surrounding forest was burned under the boiler to furnish steam to this engine. The mill soon burned down, and was replaced by another in which the power was furnished by a Sharp Brothers engine, direct-connected. As before, he spent much of his time at the new mill, and noticed that there was no slowing down during cuts, and only a few seconds' pause between them. Steam pressure was always kept up and scarcely more than half the refuse (slabs and sawdust), was required to produce it. This striking difference in performance, he realized was the result of careful design for the work to be done, and made a lasting impression on his mind. The new firm of Sharps, Davis & Bonsall, continued to build these engines, which, though without any covering on pipe or cylinder, were remarkably economical of steam, seldom requiring more fuel than the sawdust produced. Double slide valves were used, one at each end of the cylinder, drawing steam through the shortest possible ports, the area of which was generally about one-eighth of that of the piston. The engines were horizontal, the valve chests being on the top side of the cylinder. Valves were set "line on line" as to exhaust, but with sufficient outside or steam lap to cut off at three-quarters stroke, with resultant exhaust lead and compression, both of which features were favorable to economy and running qualities at such speed.

The company built a few upright blowing engines for blast-furnace work, the first of which was built for George Westerman, of Sharon, Penn., about 1863. The engine, so far as it differed from a similar one built at Cleveland, was designed by Joel Sharp. The patterns, however, together with the entire shop, were destroyed by fire April 27, 1865, and when, afterward, similar engines were called for, new patterns were made, this time from designs by Mr. Thompson, which, however, substantially the same as those of Mr. Sharp, were in the light of experience, improved in several minor respects. From this design a few engines were built, including two for the Cherry valley furnaces and one for Steubenville, O. These facts are mentioned because this designing, about 1866, was the first of any consequence

done by Mr. Thompson, who previously had served simply as a working machinist, but from that time on did much work of similar character.

In 1871 the Buckeye Engine Company was organized. It included the firm of Sharps, Davis & Bonsall with a few additional stockholders. This company promptly realized that it must come to the front and build a first-class automatic engine, and the task of producing one was assigned to Mr. Thompson. After some experimentation beginning about 1872, an engine having the characteristics of the present Buckeye, was built and the first one, with a 12x20-inch cylinder embodying the essential features that constantly have been adhered to ever since was exhibited at the Industrial Exposition at Cincinnati in 1875. The next year, 1876, another, a 16x32-inch engine, was exhibited at the Centennial Exposition in Philadelphia, and attracted much favorable comment. In this connection Mr. Thompson's name is prominently identified with the development of the shaft governor; he being one of the first, if not actually the first designer to produce a commercially practicable governor of this type. Three patents, one dated July 15, 1872, one April 27, 1875, and another January 18, 1878, cover the characteristics of the Buckeye governor, as manufactured today, with the exception of the ball and socket joint connections, for which Nathan Hunt, who had been foreman for Sharps, Davis & Bonsall, and later for the Buckeye Engine Company, was responsible.

The distinguishing features of the engine at this time were:

1. A box balanced valve on seats inside of which the cutoff valve worked. (In the later type, round piston valves containing similar cutoffs have been substituted for the box valve. This change, made to reduce the size of the valves on large engines, took place after Mr. Thompson's administration.)

2. A shaft governor controlling the angular position of an eccentric operating a cutoff valve.

3. Mechanism by which the eccentric movement, constant in amplitude, but varying in time relatively to fixed objects, is converted into a movement which is constant in amplitude relatively to the main valve. In other words, the peculiarity of the mechanism is such that the cutoff may vary with the load on the engine, but the travel of the cutoff valve on the main valve remains the same, and the formation of shoulders on the valve seats is eliminated. This valve gear is a monument to the ingenious ability of Mr. Thompson, and has been pronounced a masterpiece of mechanical design.

He perfected many other minor inventions not all of which were patented, having to do with engine details and shop appliances, but soon after the formation of the Buckeye Engine Company, and before the standard Buckeye engine was produced, a Richards indicator, the standard then used by engineers, was procured for testing the small high-speed engines then being built. It was placed in Mr. Thompson's hands for such use, but he soon found it to be very defective for the desired purpose, the inertia and momentum of its moving parts being so great as to render the diagram produced by it distorted and almost indecipherable. He was compelled to change it, which he did by dispensing with two-thirds of the weight of its moving parts, and accomplishing the parallel movement, which was the occasion of so much disturbing weight, by a simpler device which added very little to the weight of the moving part retained. The superiority of the design being realized, it began to come rapidly into use, and was known as the Thompson indicator, so that Mr. Thompson's name became much more widely known to the engineering world by reason of this improvement than through the Buckeye automatic engine, though the latter cost a thousandfold more study and brain work.

Mr. Thompson was never satisfied until he excelled in everything he undertook. Even in the matter of amusements he pushed his studies and inquiries into all branches of the subject in hand. Astronomy interested him greatly, and he delved deeply into the mechanical details of astronomical instruments, manufacturing everything himself, even grinding his own lenses. A telescope of 6-inch aperture, the product of his skill in this regard, is in use in Salem today, and another of same size remained unfinished at the time of his death.

Photography was a subject which engaged his attention when the old-time "wet plate" system was in vogue, necessitating the carrying around of a cumbersome chemical outfit, and his photographic paraphernalia, on wheels, was a familiar sight throughout the surrounding country while his interest in the science was maintained.

Among the other things with which Mr. Thompson interested himself as an amusement rather than expecting to obtain any financial benefits therefrom, was a mechanical organ and piano player very similar indeed to those which are on the market today, using the same perforated sheets in of course a more crude form. This device he perfected in the early seventies and used it first on the small house organ such as was in use in those days and afterward applied it to his piano. It did very successful work for many years.

He had a habit of studying a subject for pastime until he was thoroughly informed on it in all its phases and then dropping it for something else. This is illustrated by his experience with the game of checkers. He was an enthusiastic player until, by study and long practice, he could win from anyone in the district, when he promptly lost all interest in the game.

The life of this notable man is full of encouragement for others who follow. No doubt he was especially gifted, having a mind that was peculiarly clear sighted and far sighted in relation to mechanical problems; but his great merit was that he used his gift, bringing out of it valuable results by steady, resolute, painstaking application. He certainly had the kind of genius which has been defined as "the capacity for taking pains." At first he had serious obstacles to surmount, as he started without modern technical training, without either educational or financial advantages. It says much for both his intellectual force and his wholehearted perseverance that under these circumstances, he made his way through intelligent experimentation to scientific achievement. Perhaps the secret of his success was largely this, that whatever his hand found to do he did it with all his might. His was a generous nature. He cared less for himself than for others. Though strong in every respect, his character was without hardness, for there was no kinder man to those who were in need of kindness. The associates in his life work all pay high tribute to his genius as an inventor and philosopher, and it can be said of him that he contributed more than one individual's full measure to the world's sum total of knowledge and progress.

OBITUARY

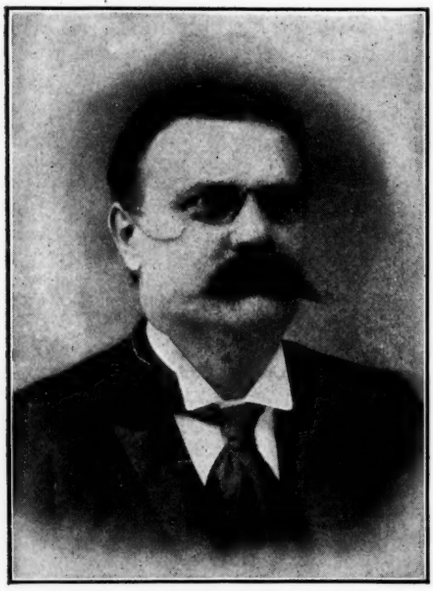
William Baxter, Jr.

William Baxter, Jr., inventor, consulting engineer and technical writer, died at his home in Jersey City on January 12 of pneumonia. Mr. Baxter was born in Troy, N. Y., on March 8, 1852, and manifested at an early age the inventive genius which he inherited from his father. The elder Baxter in 1874 did some remarkable pioneer work in the way of steam canal boats, in which he was assisted very materially by the son.

William Baxter, Jr., was a typical inventor in all commendable points. As far back as 1884, when the electric motor was mostly a laboratory possibility, he worked out a line of constant-current motors—the first ever built—and in 1886 established a factory in Baltimore for the manufacture of them. Even before that—in 1883—he appreciated the advantages of inclosing the arc of an arc lamp in an air-tight globe, and took out patents covering such construction. This invention was also marketed for several years, but it was ahead of its time. In 1887 Mr. Baxter became interested in the electric-hoist problem and

during the years immediately following he invented and patented some methods and devices which for many years were amongst the most important of those controlled by the Otis Elevator Company, to whom he sold his patents. In 1888, for example, he filed an application for a patent covering the use of a switch on the car, operated by the attendant to control the motor which hoists the car, and this patent was issued in March, 1891. This same patent covers broadly the use of a switch opened automatically by the car at each end of its travel to stop the motor—the now well known top and bottom limit switches.

Mr. Baxter was also one of the pioneers in the electric-railway field, and his Baltimore company built an experimental car about 1893 which showed promising features. In this field, also, Mr. Baxter's ideas were too far ahead of the march of progress for commercial success. One of the handicaps of his



WILLIAM BAXTER, JR.

system was the use of laminated field magnets and another was the mounting of the motor armatures directly on the car axles to eliminate gears.

Like so many meritorious inventors, Mr. Baxter lacked the business ability to reap the full reward of his genius. His elevator patents alone should have made him independently wealthy—but they didn't.

Mr. Baxter's name is familiar to readers of POWER who are interested in elevators of any type. He was the author of the comprehensive series of articles on hydraulic elevators which ran through a year or more and of the series on electric elevators now in course of publication. His death will not cut the present series off abruptly, but it will cause the abandonment of a few descriptions which he intended to prepare later on.

NEW PUBLICATIONS

THE MODERN GAS ENGINE AND GAS PRODUCER. By A. M. Levin. Published by John Wiley & Sons, New York, 1910. Cloth; 500 pages, 6x9 inches; 181 illustrations; 36 tables. Price, $4.

With the most friendly motives, the reviewer respectfully urges Mr. Levin to enlist the services of a competent editor and revise his first edition comprehensively. The author evidently knows his subject unusually well, but his methods of expression are unfortunate. One of the lesser examples of this kind occurs in the second line of the first chapter: "Thermodynamics concerns itself" with pressures, volumes and heat, etc. We were unaware that thermodynamics was in the habit of giving itself any concern whatever. A worse example is the use of the term "carbureted gasolene;" in the course of a close study of the internal-combustion engine during the past ten years the reviewer has never come across any "carbureted" gasolene. Neither has he ever seen any gasolene of any grade the vapor of which required 54 volumes of air for combustion, which the author states, on page 125, is the case; possibly this is the "carbureted" grade. The author also appears to have discovered "carbureted" kerosene (page 130), which is equally unknown to the reviewer. All through the book he uses the inept expression "heating value," meaning heat value or calorific value in thermal units. Logically, the heating value of any substance depends on its temperature, which is only connected obliquely with its heat value.

Technically, the book is remarkably free from errors and prolixity; Mr. Levin's principles, so far as the reviewer has had time to analyze them, are quite beyond cavil and his explanations are well condensed and direct, and would be most clear if his literary "usage" were less erratic. Chapter VIII, dealing with the practical gas-engine cycle, is particularly good, technically, although the use of the coefficient y to cover the discrepancy between theoretical and actual values of mean effective pressure seems an unnecessary refinement in view of the fact that no rational estimate can be made of its value, which ranges from about 0.5 to something like 1.5, according to a number of erratic and independent variables in operating conditions.

Chapters IX, X and XI, devoted to mechanical details, are especially praiseworthy; it is regrettable, however, that the author gave such scanty attention to piston-rod packing, which is a serious problem in large engines; his effort in this direction is restricted to a rather perfunctory description of the Schwabe packing. The chapter on methods of governing needs to be brought up to date, and the explanation of the methods used by the Allis, Snow and Westinghouse companies should be included in this chapter instead of being buried in a mass of engine descriptions in Chapter XIV.

The chapter on producers is excellent as far as it goes, but its scope should be increased to cover all of the representative types of producer plant.

The test data in the appendix are inadequate; an instructive analysis of the performances is impossible from the data given.

Finally, the reviewer must in fairness emphasize the fact that the adverse portions of this commentary are written with a sincere desire to see the next edition of Mr. Levin's book brought up to the plane that its intrinsic merit deserves; it would be most deplorable to allow a fundamentally fine effort to be largely nullified by the easily corrected blemishes noted.

PERSONAL

R. C. Carpenter and E. H. Faile announce that they have formed a partnership for the practice of engineering and will specialize in the mechanical and electrical equipment of buildings, including power plants, heating, ventilating, sanitary work, elevators and illumination. Office at 68 William street, New York City.

J. E. Coyle, who was connected with the Best American Calorific Company until they retired from business, is now with the Rockwell Furnace Company, making a specialty of oil and gas furnaces for railroad work. Mr. Coyle is an experienced railroad man, having formerly been master blacksmith for the "Lehigh" at Wilkes-Barre, and later in charge of the drop hammer and machine department at the forge shops of the "Reading" at Reading, Penn.

Meeting of A. I. E. E. at Charlotte, N. C.

The Meetings and Papers Committee of the American Institute of Electrical Engineers has arranged for a meeting of the Institute at Charlotte, N. C., on March 23, 24 and 25, 1910. The program has not yet been completed, but arrangements have already been made for the presentation of the following papers: Economics of Hydroelectric Plants, by W. S. Lee; Electric Drive in Textile Mills, by A. Milmow; Calcium Cyanamide and Its Relation to Water Powers, by Charles H. Baker; Gas Engines in City Railway and Light Service, by E. D. Latta, Jr.; Protective Devices for High-Tension Transmission Lines, by L. C. Nicholson. In addition to a number of attractive social features, the

Southern Power Company has offered to place at the disposal of the members in attendance, a special train for a tour of inspection of its Great Falls station at Great Falls, S. C., and a 100,000-volt substation. The official headquarters will be at the Selwyn hotel. A local committee of arrangements has been appointed by President Stillwell, with W. S. Lee as chairman. It is hoped that a representative attendance, especially of the southern membership, will be present. The Charlotte meeting is not to take the place of the Institute's annual convention, which will be held as usual later in the year at a place not yet decided upon.

SOCIETY NOTES

The Illinois Visiting and Traveling Club, composed of well known engineers of Chicago, paid a visit to the Elgin N. A. S. E. association No. 49 on the evening of January 13. Candidates were initiated and refreshments served, after which an enjoyable entertainment was provided by the local association.

The monthly meeting of the American Society of Mechanical Engineers, held at the Engineering Societies building on Tuesday, February 8, will be a Thurston memorial. The bronze tablet of Dr. R. H. Thurston, recently mounted in the corridor of the society's headquarters, will be formally dedicated, and there will be a number of addresses by eminent speakers.

At the regular monthly meeting of the Polytechnic Institute Student Section of the American Society of Mechanical Engineers, held in the library of the Institute, Saturday, January 8, at 8 p.m., Leon B. Lent, New York manager of the Riverside Gas Engine Company, delivered a lecture on Modern Gas Engines, illustrated by some sixty lantern slides covering the salient features of the various types of gas engines. The lecture was followed by a lively discussion, after which the audience adjourned to the president's parlor where a collation was served.

The annual meeting of the Chicago Steam Engineers' Club was held at the club rooms, 510 Hartford building, Tuesday evening, January 11, the old officers, John F. McGrath, president; Thomas W. McNeill, vice-president; Jacob Reitz, secretary; Alfred Johnson, treasurer, all being reëlected, to serve for the coming year. Robert E. Hills, George Dohm and John W. Lane, members of the board of governors, were retained to serve their unexpired terms and Alfred Myers and O. Monnett were elected members of the board to serve for two years. The club has a total of 86 members and the annual report of the secretary shows it to be in excellent financial condition. Plans were discussed at the meeting for taking larger quarters and adding additional facilities to the equipment of the club rooms.

The annual dinner of the Western Society of Engineers took place on the evening of January 12 at the University Club, Chicago. Mr. Allen, the retiring president, reviewed the accomplishments of the past year and the newly elected officers were duly installed as follows: J. W. Alvord, president; O. P. Chamberlain, vice-president; A. Bement, second vice-president; W. K. Hatt, third vice-president; A. Reichman, treasurer; trustee for one year, L. E. Ritter; for two years, G. M. Brill; and for three years, W. W. Curtis. The past presidents on the board of direction are W. L. Abbott, C. F. Loweth and Andrews Allen. In assuming the duties of president Mr. Alvord spoke very optimistically of plans for the coming year and said that the opportunities for the modern engineer were better than they ever had been in the past. J. H. Warder is secretary, with offices at the headquarters of the society, 1735 Monadnock block.

As over two thousand admission tickets were taken at the door, it can be easily imagined what a successful affair was the eighth annual entertainment and reception of the combined associations of the N. A. S. E., of Manhattan and Bronx held at the Grand Central Palace, Saturday evening, January 15. The program opened with the N. A. S. E. Mammoth Minstrels, given by the "Bunch," assisted by the Bay Ridge Athletic Club; this was followed by several professional vaudeville acts, after which the floor was cleared for dancing. At 3 a.m. a banquet was tendered to the visiting National officers and guests at Terrace Garden, the party being conveyed there by means of auto buses. The National officers present included, President Reynolds, Treasurer Force and Secretary Raven; Past National Presidents, Lahey, Wheeler, Stone, Hogan and Carney; there were also delegations of visitors from New England, Philadelphia, Pittsburg, Chicago, etc. The several committees in charge are to be congratulated upon the success of their efforts. The officers of the General Committee are James R. Coe, chairman; Asher Nelson, vice-president; William M. Logan, treasurer; J. Douglas Taylor, secretary. The raising of funds for the carrying out of the committee's wishes was intrusted to the Supply Men's Association of Greater New York, who raised over $1000 for the committee.

Engineering Societies

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Jesse M. Smith, New York, N. Y.; sec., Calvin W. Rice, Engineering building; 29 West 39th St., New York. Monthly meetings in New York City. Spring meeeting at Atlantic City, May 31 to June 6.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff, Denver, Colo.; sec. and treas., Frank M. Tait. Association headquarters, 29 West Thirty-ninth St., New York.

ENGINEERS' CLUB OF PHILADELPHIA

Pres., William Easby, Jr.; sec., W. P. Taylor, 1317 Spruce St. Regular meetings 1st and 3d Saturdays.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Navy Dept., Washington, D. C. Pres., Rear Admiral John K. Barton (retired) U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, Cleveland, O.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1737 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., George T. Barnsley; sec., E. K. Hiles, 803 Fulton building, Pittsburg, Pa. Meetings 1st and 3d Tuesdays.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., L. B. Stillwell; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly, excepting July and August.

ENGINE BUILDERS' ASSOCIATION OF THE UNITED STATES

Pres., A. L. Merriam, Oswego, N. Y.; sec., C. H. Sembower, Reading, Pa.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, W. S. Cadwell, Chicago, Ill.; sec., Thomas H. Jones, 244 Eighth street, N. E., Washington, D. C. Next convention, Buffalo, N. Y., August, 1910.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., William J. Reynolds, Hoboken, N. J.; sec., F. W. Raven, 525 Manhattan building, Chicago, Ill. Next convention, Rochester, N. Y., September, 1910.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next convention, Philadelphia, Pa., June, 1910.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; sec. and treas., Prof. F. E. Sanborn, Ohio State University, Columbus, Ohio.

MASTER STEAM BOILER MAKERS' ASSOCIATION

Pres., J. H. Smyth; sec., Geo. M. Clark, 1337 N. Maplewood Ave., Chicago, Ill.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., Robert A. McKee, Peoria, Ill. Next convention, Denver, Colo., September, 1910.

NATIONAL DISTRICT HEATING ASSOCIATION.

Pres., A. C. Rogers, Toledo, O.; sec. and treas., D. L. Gaskill, Greenville, O. Next annual meeting at Toledo, O., May, 1910.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATION.

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, Washington, D. C., January 17-21, 1910.

Business Items

The Triumph Engineering and Supply Company, 253 La Salle street, Chicago, Ill., has just taken over the exclusive United States selling rights for Cassco bar metallic packing.

A 10,000-kilowatt Westinghouse-Parsons turbine-driven unit has been installed at the plant of the Metropolitan Street Railway Company, of Kansas City, Mo. The plant is about ready for a test.

Recent sales of the Crocker-Wheeler Company aggregate more than 5000 horsepower in direct-current motors and approximately 2000 kilowatts in direct-current generators and 2000 k.v.a. in alternating-current generators.

The McCloud River Lumber Company, McCloud, Cal., has placed an order with Allis-Chalmers Company for one 26x48 heavy-duty belted engine to be used in its mill. This is a noncondensing engine and will operate under a steam pressure of from 125 to 150 pounds.

The Cutler-Hammer Manufacturing Company, of Milwaukee, well known in the electrical trade as builders of high-grade apparatus for the control of motors and generators, has found it necessary to erect a factory in New York to take care of the enormous growth of its business. The new eastern factory is located in Bronx borough, is five stories high, of steel and brick construction, and contains about 100,000 square feet of floor space.

The Lagonda Manufacturing Company, of Springfield, Ohio, has just published an interesting pamphlet entitled, "Scale and the Vacuum." This describes some of the new cleaners especially suited for removing scale from the tubes of surface condensers, ammonia condensers, etc., which they have recently developed. It also contains valuable tables showing the losses in horsepower resulting from the reduction in vacuum, due to the formation of scale in condenser tubes. Copies will be supplied free upon request.

The Detroit Copper and Brass Rolling Mills Company, Detroit, Mich., has recently placed an order with Allis-Chalmers Company for additional machinery for its power plant as follows: One 750-kilowatt, 480-volt, 60-cycle, three-phase alternator direct connected to a low-pressure turbine turning 3600 revolutions per minute and operating under a pressure of 17½ pounds absolute and a vacuum of 28 inches referred to a 30-inch mercury column. The vacuum will be maintained by a Tomlinson type "C" condenser. There will also be installed a 200-kilowatt synchronous motor generator set furnishing direct current at 240 volts.

W. J. Best, for the past three years Chicago sales manager and engineer for the Buckeye Engine Company, has taken a position with the Wheeler Condenser and Engineering Company, Carteret, N. J., with the title of treasurer. Before his connection with the Buckeye Engine Company, Mr. Best was for five years sales engineer with the Green Fuel Economizer Company, in their Chicago office, having previously been erecting engineer for E. F. Williams, in which capacity he put in many large steam power stations. Besides acting as treasurer for the Wheeler Condenser and Engineering Company, Mr. Best will also have charge of part of the sales and engineering work.

The Republic Rubber Company, of Youngstown, Ohio, has announced that it has acquired the patent and trade-mark rights for Balata belting for this country. The manufacture of Balata belting has formerly been confined to Irwell & Easton Rubber Works, Sarford, Manchester, England. Considerable Balata belting has been used in this country for a number of years, and all of it has been imported. The president and general manager of the English company are directing the establishment of the new plant at Youngstown, and within a few months, will be prepared to supply this material to manufacturers without the delay and expense incident to importation.

The B. F. Sturtevant Company, Hyde Park, Mass., has published a new catalog No. 150, illustrating and describing the Sturtevant new high pressure type economizer; this type of economizer with all joints metal-to-metal, will, it is claimed, stand all working pressures up to 300 pounds per square inch, and with the doing away with gasket joints in this design, eliminates chance of leakage. In the Sturtevant design a positive scraper mechanism is used; the scrapers, they claim, cannot stick or bind which eliminates one of the troubles found in earlier designs of economizers. As this catalog shows not only the design and gives dimensions of the economizer, but also shows examples of the investment returns on an economizer, it will be found of interest to engineers, managers and owners.

The Bruce-Macbeth Engine Company, of Cleveland, Ohio, is just about to install for the Municipal lighting plant of the city of Canal Dover, Ohio, one of its 250-horsepower vertical, 4-cylinder gas engines, direct connected to 175-kilowatt, alternating-current generator. This company has also sold a duplicate of this engine to the Willard Storage Battery Company, Cleveland, which will make the fourth engine they have installed at that plant. Through its Buffalo representatives, the Sterns Electric Equipment Company, it has also sold one of these 250-horsepower, 4-cylinder engines to the E. R. Thomas Motor Company, Buffalo. This will also be the fourth engine it has installed at this plant. They also report a fourth sale of a 135-horsepower, 4-cylinder engine to the Monongah Glass Company, Fairmont, W. Va.

F. R. Clark, secretary and treasurer of the Climax Road Machine Company, Marathon, N. Y., in a recent letter to the Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, says: "We duly received your favor of the nineteenth in which you wrote us in relation to a skimmer for our other boiler. We did not reply to your letter at that time for the reason that we had not as yet had time to look over the boiler in which we installed the other skimmer and ascertain what satisfaction the skimmer has given. We have just looked the matter up and are pleased to find the skimmer has given the best of satisfaction and we believe it is just what we want to overcome the troubles we are having with our boilers. We therefore have decided to place another of these skimmers in our other boiler, and we would thank you to ship us an outfit similar to the one we bought earlier in the season."

The San Francisco office of the Power Specialty Company, formerly in the Kohl building, has been transferred to larger quarters in the Balboa building on Market street, adjoining the new Palace hotel, and has been placed in charge of Chas. L. Froding, formerly manager of the San Francisco office of the Sterling Boiler Company. Since the initial installation of Foster superheaters in the 6000-horsepower Oakland plant of the Pacific Gas and Electric Company, orders have been taken by the San Francisco office for the equipment of the various pumping stations on the Associated Pipe Lines; several high-temperature superheaters for the Union Oil Company for process work, and for a number of large lumber companies which have adopted the modern method of drying lumber by superheated steam. Orders for standard equipment have also been received from the Pacific Engineering Company, the Risdon Iron Works and the United States Mint.

New Equipment

Lake City, Minn., will purchase a 250- or 300-horsepower boiler with stoker in the near future.

Otto Eisenlohr & Bro., 940 Market street, Philadelphia, Penn., will erect a four-story cigar factory at Reading, Penn.

The Pine Beach Improvement Company, Hale building, Philadelphia, Penn., will erect a power plant at Pine Beach, N. J.

Plans are being prepared by J. V. Poley, engineer, Royersford, Penn., for a four-story mill for the National Underwear Company, Spring City, Penn.

J. V. Poley, engineer, Royersford, Penn., is preparing plans for a boiler house and an addition to the plant of the Century Knitting Company, Spring City, Penn.

Stanley G. Flagg & Co., 424 North Nineteenth street, Philadelphia, Penn., are having plans drawn for an engine house and gas-producer plant at their plant in Pottstown, Penn.

David Pepper, engineer, Commonwealth building, Philadelphia, Penn., will draw plans for an electric-lighting plant at Meadowbrook, Penn., for the Seybert Institute for Poor Children.

Carl P. Berger, Penn Square building, Philadelphia, Penn., is receiving estimates for alterations to the plant of the Steel Heddle Manufacturing Company, Philadelphia, Penn.

Ballinger & Perrot, 1211 Arch street, Philadelphia, Penn., are receiving bids on additional buildings at the wall-paper plant of the Jacob Thomas Company, Newark, Del., including mill building, color-mixing plant and boiler house.

The Lakewood Terrace Hotel and Sanitarium Company, Witherspoon building, Philadelphia, Penn., has authorized T. B. Shertzer, 23 Flatbush avenue, Brooklyn, N. Y., to prepare plans for an electric light and power plant, water supply and sewerage disposal plant at Lakewood, N. J.

Bids have been received by Wilson, Harris & Richards, architects and engineers, Drexel building, Philadelphia, Penn., for the construction of a 17-story apartment building for Frank Mauran, Land Title building. This will cost $500,000 power equipment to consist of two electric driven pumps, three 125-horsepower and one 50-horsepower boilers, two feed pumps, two vacuum pumps and four electric elevators.

New Catalogs

Joseph Dixon Crucible Company, Jersey City, N. J. Pamphlet. "Graphite as a Lubricant." Illustrated, 60 pages, 6x9 inches.

The Ohio Grease Lubricant Company, Loudonville, Ohio. Booklet. Grease cylinder lubrication. Illustrated, 4½x6½ inches, 24 pages.

The Service Pump Company, Orrville, Ohio. Catalog No. 1. Conkell steam and air pumps, condensers and air compressors. Illustrated, 32 pages, 6x9 inches.

Alexander Miller & Bro., Jersey City, N. J. Pamphlet. Pure Feed Water from Condensation Water. Krause patented oil absorbent process. 8 pages, 5x7 inches.

Chas. A. Claflin & Co., 60 High street, Boston, Mass. Catalog. Steam and vacuum tube cleaners, hose fittings, balanced valves, etc. Illustrated, 24 pages, 6x9 inches.

John T. Lindstrom Machine Works, 214 S. Third street, Allentown, Penn. Catalog. Corliss valve steam trap and steam separators. Illustrated, 30 pages, 5x6½ inches.